```
# gerardo Herrera... random forest (500 arboles) con 28k instacias de normal y recovering y 2


import numpy as np
import pandas as pd
import os

import matplotlib.pyplot as plt
%matplotlib inline
from tqdm import tqdm_notebook
from sklearn.preprocessing import StandardScaler
from sklearn.metrics import mean_absolute_error
pd.options.display.precision = 15

import time
# Libraries
import numpy as np
import pandas as pd
pd.set_option('max_columns', None)
import matplotlib.pyplot as plt
import seaborn as sns
%matplotlib inline

!pip install lightgbm
!pip install catboost

import datetime
import lightgbm as lgb
from scipy import stats
from sklearn.model_selection import train_test_split, StratifiedKFold, KFold, cross_val_score
from sklearn.preprocessing import StandardScaler
import os
import lightgbm as lgb
from sklearn.metrics import accuracy_score, roc_auc_score
from sklearn import metrics
from sklearn import linear_model
from tqdm import tqdm_notebook
from catboost import CatBoostClassifier
```

```
Requirement already satisfied: lightgbm in /usr/local/lib/python3.6/dist-packages (2.2.
Requirement already satisfied: scipy in /usr/local/lib/python3.6/dist-packages (from li
Requirement already satisfied: numpy in /usr/local/lib/python3.6/dist-packages (from li
Requirement already satisfied: scikit-learn in /usr/local/lib/python3.6/dist-packages (
Requirement already satisfied: joblib>=0.11 in /usr/local/lib/python3.6/dist-packages (
Collecting catboost
  Downloading https://files.pythonhosted.org/packages/52/39/128fff65072c8327371e3c594f3
     |████████████████████████████████| 66.2MB 61kB/s
Requirement already satisfied: graphviz in /usr/local/lib/python3.6/dist-packages (from
Requirement already satisfied: numpy>=1.16.0 in /usr/local/lib/python3.6/dist-packages (
```

```
Requirement already satisfied: six in /usr/local/lib/python3.6/dist-packages (from catbo
Requirement already satisfied: matplotlib in /usr/local/lib/python3.6/dist-packages (fro
Requirement already satisfied: pandas>=0.24.0 in /usr/local/lib/python3.6/dist-packages 
Requirement already satisfied: scipy in /usr/local/lib/python3.6/dist-packages (from cat
Requirement already satisfied: plotly in /usr/local/lib/python3.6/dist-packages (from ca
Requirement already satisfied: kiwisolver>=1.0.1 in /usr/local/lib/python3.6/dist-packag
Requirement already satisfied: python-dateutil>=2.1 in /usr/local/lib/python3.6/dist-pac
Requirement already satisfied: cycler>=0.10 in /usr/local/lib/python3.6/dist-packages (f
Requirement already satisfied: pyparsing!=2.0.4,!=2.1.2,!=2.1.6,>=2.0.1 in /usr/local/li
Requirement already satisfied: pytz>=2017.2 in /usr/local/lib/python3.6/dist-packages (f
Requirement already satisfied: retrying>=1.3.3 in /usr/local/lib/python3.6/dist-packages
Installing collected packages: catboost
Successfully installed catboost-0.24.2
```

```
from google.colab import drive
drive.mount('/content/drive')
```

```
Mounted at /content/drive
```

```
# sensor = pd.read_csv('../input/sensor.csv')
# sensor = pd.read_csv('../input/vombas/sensor_procesado.csv')
#sensor = pd.read_csv('dataset_sensor_procesado.csv')
#sensor = pd.read_csv('../input/bombas-sensores-conocidos/sensor2.csv')
#sensor = pd.read_csv('../input/28k-s24-balan-vombas/sensor2-ordenado_status_sin_broken_balan
#sensor.drop(['Unnamed: 0'], axis=1, inplace=True)

sensor = pd.read_csv('/content/drive/My Drive/datasets/sensor2-ordenado_status_sin_broken_bal
```

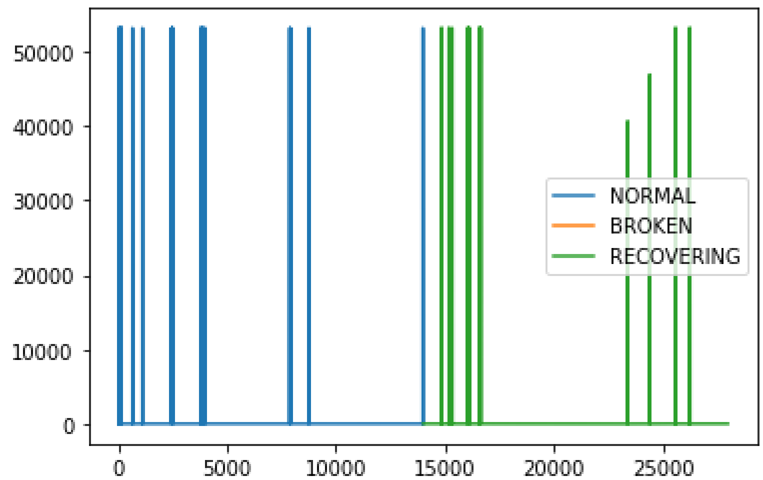
```
sensor.head()
```

Unnamed: timestamp sensor_00 sensor_01 sensor_02 sens

```
#sensor.drop(['sensor_15'], axis=1, inplace=True)
sensor.drop(['timestamp'], axis=1, inplace=True)
```

```
# lineA DE LOS 22K INSTANCIAS
plt.plot(sensor.loc[sensor['machine_status'] == 'NORMAL', 'sensor_02'], label='NORMAL')
plt.plot(sensor.loc[sensor['machine_status'] == 'BROKEN', 'sensor_02'], label='BROKEN')
plt.plot(sensor.loc[sensor['machine_status'] == 'RECOVERING', 'sensor_02'], label='RECOVERING
plt.legend()
```

<matplotlib.legend.Legend at 0x7f5d05b9b470>




```
cleanup_nums = {"machine_status":     {"NORMAL": 0, "RECOVERING": 1,"BROKEN": 2}}
```

```
sensor.replace(cleanup_nums, inplace=True)
sensor.head(30)
```

	Unnamed: 0	sensor_00	sensor_01	sensor_02	sensor_03
0	0	2.465394	47.092010000000002	53.211799999999997	46.310760000000002
1	1	2.465394	47.092010000000002	53.211799999999997	46.310760000000002
2	2	2.444734	47.352429999999998	53.211799999999997	46.397570000000002
3	3	2.460474	47.092010000000002	53.168399999999998	46.397567749023402
4	4	2.445718	47.135410000000000	53.211799999999997	46.397567749023402
5	5	2.453588	47.092010000000002	53.168399999999998	46.397567749023402
6	6	2.455556	47.048609999999996	53.168399810790994	46.397567749023402
7	7	2.449653	47.135410000000000	53.168399810790994	46.397567749023402
8	8	2.463426	47.092010000000002	53.168399810790994	46.397567749023402
9	9	2.445718	47.178820000000002	53.168399999999998	46.397567749023402
10	10	2.464410	47.482640000000004	53125.000000000000000	46.397567749023402
11	11	2.444734	47.916660000000000	53.168399999999998	46.397567749023402
12	12	2.460474	48.263890000000004	53125.000000000000000	46.397567749023402
13	13	2.448669	48.437500000000000	53.168399999999998	46.397567749023402
14	14	2.453588	48.567709999999998	53.168399999999998	46.397567749023402
15	15	2.455556	48.394100000000002	53125.000000000000000	46.397570000000002
16	16	2.449653	48.394100000000002	53.168399999999998	46.310760000000002
17	17	2.463426	48.480899999999998	53.689240000000012	46.310760498046896
18	18	2.445718	48.611109999999996	53125.000000000000000	46.310760498046896
19	19	2.464410	48.611109999999996	53.168399999999998	46.310760498046896

```
for col in sensor.columns[1:-1]:
    sensor[col] = sensor[col].fillna(sensor[col].mean())


# bosque aleatorio
```

23	23	2.453588	49.088540000000002	53.168399999999998	46.267360687255895

```
sensor.fillna(sensor.mean(), inplace=True)
```

```
sensor.head()
```

	Unnamed: 0	sensor_00	sensor_01	sensor_02	sensor_03	
0	0	2.465394	47.092010000000002	53.211799999999997	46.310760000000002	6343
1	1	2.465394	47.092010000000002	53.211799999999997	46.310760000000002	6343
2	2	2.444734	47.352429999999998	53.211799999999997	46.397570000000002	6

```
print(sensor.shape)
```

```
(28002, 26)
```

```
# Encontrar características importantes en Scikit-learn

# from sklearn.ensemble import RandomForestClassifier

#Create a Gaussian Classifier
#clf=RandomForestClassifier(n_estimators=100)

#Train the model using the training sets y_pred=clf.predict(X_test)
#clf.fit(X_train,y_train)


# no correr
#import pandas as pd
#feature_imp = pd.Series(clf.feature_importances_,index=iris.feature_names).sort_values(ascen
#feature_imp = pd.Series(clf.feature_importances_,index=sensor.columns[19:27]).sort_values(as
#print(feature_imp)

#Visualización
#import matplotlib.pyplot as plt
#import seaborn as sns
#%matplotlib inline
# Creating a bar plot
#sns.barplot(x=feature_imp, y=feature_imp.index)
# Add labels to your graph
#plt.xlabel('Feature Importance Score')
#plt.ylabel('Features')
#plt.title("Visualizing Important Features")
#plt.legend()
#plt.show()



X=sensor[['sensor_00', 'sensor_01', 'sensor_02', 'sensor_03','sensor_04', 'sensor_11', 'senso
#y=sensor['target']  # Labels
y=sensor['machine_status']  # Labels

# Split dataset into training set and test set
#X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.3) # 70% training and
```

```
# Split dataset into training set and test set
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2) # 80% training and 2


from sklearn.ensemble import RandomForestClassifier

#Create a Random Forest Classifier
clf=RandomForestClassifier(n_estimators=500)

start = time.time()

#Train the model using the training sets y_pred=clf.predict(X_test)
clf.fit(X_train,y_train)

stop = time.time()
print(f"Training time: {stop - start}s")

y_pred=clf.predict(X_test)

#Import scikit-learn metrics module for accuracy calculation
from sklearn import metrics
# Model Accuracy, how often is the classifier correct?
print("Accuracy:",metrics.accuracy_score(y_test, y_pred))

#predicciones del item 17156 q es 1
clf.predict([[0.0,53.55902,52.77777,43.402774810790994,204.72509765625,3.7302410000000004,404
```

```
Training time: 13.407578945159912s
Accuracy: 1.0
array([1])
```

```
#predicciones
clf.predict([[0.0,53.55902,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0]])
```

```
array([1])
```

```
#predicciones
clf.predict([[0.0,53.55902,52.77777,43.402774810790994,204.72509765625,3.7302410000000004,404
```

```
array([1])
```

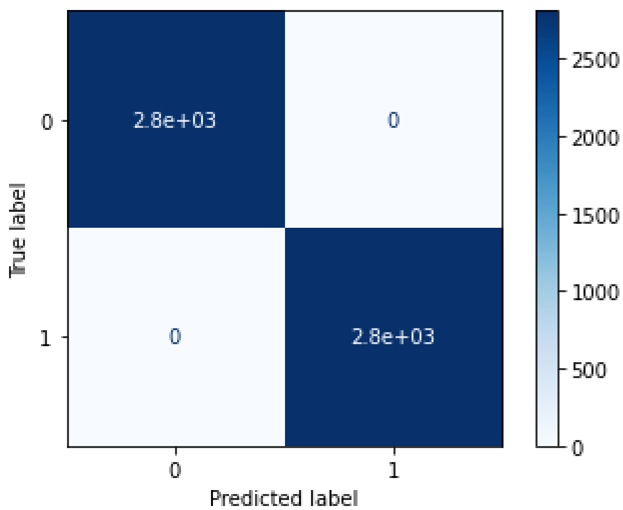
```
# Extract single tree
estimator = clf.estimators_[5]


#from sklearn.tree import export_graphviz
# Export as dot file
#export_graphviz(estimator, out_file='tree.dot',
#                 feature_names = ['sensor_00', 'sensor_01', 'sensor_02', 'sensor_03','sensor_
```

```
#                 feature_names = [ 'sensor_00', 'sensor_01', 'sensor_02', 'sensor_03', 'sensor_
#                 class_names = [ 'machine_status'],
 #                rounded = True, proportion = False,
 #                precision = 2, filled = True)


# validacion cruzada
# https://jamesrledoux.com/code/k_fold_cross_validation


from sklearn.model_selection import cross_validate


start1 = time.time()
model = RandomForestClassifier(random_state=1)
cv = cross_validate(model, X, y, cv=10)
print(cv['test_score'])
print(cv['test_score'].mean())
stop1 = time.time()
print(f"Training time: {stop1 - start1}s")
```

```
[0.99464477 0.99964298 1.         1.         1.         1.
 1.         1.         1.         0.85642857]
0.9850716325802009
Training time: 28.07333517074585s
```

```
#https://stackoverflow.com/questions/20662023/save-python-random-forest-model-to-file


from sklearn.metrics import classification_report, confusion_matrix
import matplotlib.pyplot as plt
from sklearn.metrics import plot_confusion_matrix

start1 = time.time()
#model = RandomForestClassifier(random_state=1)
model = RandomForestClassifier(n_estimators=500)

cv = cross_validate(model, X, y, cv=10)
print(confusion_matrix(y_test,y_pred))
print(cv['test_score'])
print(cv['test_score'].mean())
stop1 = time.time()
print(f"Training time: {stop1 - start1}s")

print(confusion_matrix(y_test,y_pred))
print(classification_report(y_test,y_pred))

#plot_confusion_matrix(clf, X_test, y_test)
# plot_confusion_matrix(clf, X_test, y_test)
plot_confusion_matrix(clf, X_test, y_test, cmap=plt.cm.Blues)

plt.show()
```

```
[[2792    0]
 [   0 2809]]
[0.99393074 0.99964298 1.         1.         1.         1.
 1.         1.         1.         0.88071429]
0.9874288009384402
Training time: 139.9744303226471s
[[2792    0]
 [   0 2809]]
              precision    recall  f1-score   support

           0       1.00      1.00      1.00      2792
           1       1.00      1.00      1.00      2809

    accuracy                           1.00      5601
   macro avg       1.00      1.00      1.00      5601
weighted avg       1.00      1.00      1.00      5601
```




```
# version with multi scoring
from sklearn.metrics import classification_report, confusion_matrix
import matplotlib.pyplot as plt
from sklearn.metrics import plot_confusion_matrix

start1 = time.time()
#model = RandomForestClassifier(random_state=1)
model = RandomForestClassifier(n_estimators=500)

cv = cross_validate(model, X, y, cv=10)
#recall_score=cross_validation.cross_val_score(clf, X,y, cv=10, scoring ='recall')
#recall_score=cross_val_score(model, X,y, cv=10, scoring ='recall')
f1=cross_validate(model, X,y, cv=10, scoring ='f1')
recall_score=cross_validate(model, X,y, cv=10, scoring ='recall')
pre_score=cross_validate(model, X,y, cv=10, scoring ='precision_macro')
print(confusion_matrix(y_test,y_pred))
print(f"precision_macro_score:")
print(pre_score['test_score'])
print(pre_score['test_score'].mean())
print(f"test_score:")
print(cv['test_score'])
```

```
print(cv['test_score'].mean())
print(f"recall:")
print(recall_score['test_score'])
print(recall_score['test_score'].mean())
print(f"f1score:")
print(f1['test_score'])
print(f1['test_score'].mean())
stop1 = time.time()
print(f"Training time: {stop1 - start1}s")

print(confusion_matrix(y_test,y_pred))
print(classification_report(y_test,y_pred))

#plot_confusion_matrix(clf, X_test, y_test)
# plot_confusion_matrix(clf, X_test, y_test)
plot_confusion_matrix(clf, X_test, y_test, cmap=plt.cm.Blues)

plt.show()
```

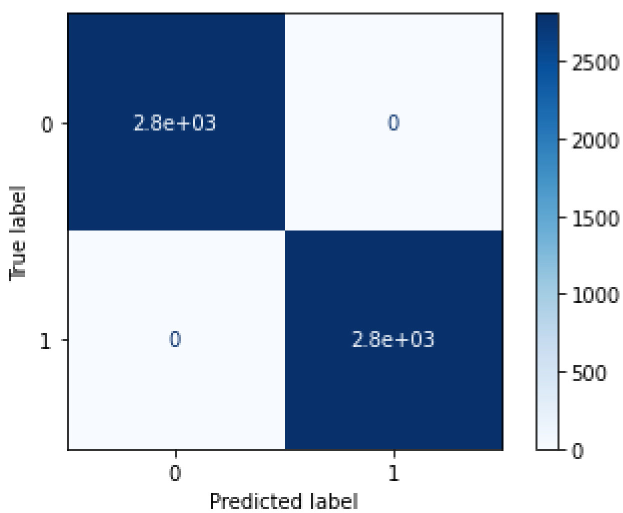
```
[[2792    0]
 [   0 2809]]
precision_macro_score:
[0.9975142  0.99964311 1.         1.         1.         1.
 1.         1.         1.         0.92225241]
0.9919409723151702
test_score:
[0.99393074 0.99964298 1.         1.         1.         1.
 1.         1.         1.         0.88857143]
0.9882145152241545
```

```
# version with multi scroring mejorada
from sklearn.metrics import classification_report, confusion_matrix
import matplotlib.pyplot as plt
from sklearn.metrics import plot_confusion_matrix

start1 = time.time()
#model = RandomForestClassifier(random_state=1)
model = RandomForestClassifier(n_estimators=500)

#GH
model.fit(X_train,y_train)
y_pred=model.predict(X_test)
#GH

cv = cross_validate(model, X, y, cv=10)
#recall_score=cross_validation.cross_val_score(clf, X,y, cv=10, scoring ='recall')
#recall_score=cross_val_score(model, X,y, cv=10, scoring ='recall')

#scoring = ['neg_mean_absolute_error','r2']

scores=cross_validate(model, X,y, cv=10, scoring = ['accuracy','f1','recall','precision'],ret
#recall_score=cross_validate(model, X,y, cv=10, scoring ='recall')
#pre_score=cross_validate(model, X,y, cv=10, scoring ='precision_macro')
print(confusion_matrix(y_test,y_pred))

print(f"multi_metric_scores:")
#print(scores['test_score'])
print(scores)
#print(scores['test_score'].mean())

#print(scores.mean())

#print(f"precision_macro_score:")
#print(pre_score['test_score'])
#print(pre_score['test_score'].mean())

#print(f"test_score:")
#print(cv['test_score'])
#print(cv['test_score'].mean())

#print(f"recall:")
#print(recall_score['test_score'])
```

```
#print(recall_score['test_score'].mean())

#print(f"f1score:")
#print(f1['test_score'])
#print(f1['test_score'].mean())

stop1 = time.time()
print(f"Training time: {stop1 - start1}s")

print(confusion_matrix(y_test,y_pred))
print(classification_report(y_test,y_pred))

#plot_confusion_matrix(clf, X_test, y_test)
# plot_confusion_matrix(clf, X_test, y_test)
plot_confusion_matrix(clf, X_test, y_test, cmap=plt.cm.Blues)

plt.show()

gh4 = scores.get("test_accuracy")

print(f"accuracy:")
print(gh4)
print(gh4.mean())

gh3 = scores.get("test_precision")

print(f"precision:")
print(gh3)
print(gh3.mean())

gh = scores.get("test_recall")

print(f"recall:")
print(gh)
print(gh.mean())

gh2 = scores.get("test_f1")

print(f"f1:")
print(gh2)
print(gh2.mean())

CM = confusion_matrix(y_test, y_pred)
print(f"--------")
print(f"matriz de confusion:")
TN = CM[0][0]
FN = CM[1][0]
TP = CM[1][1]
FP = CM[0][1]
print(f"TN={TN}, FP={FP} ")
print(f"FN={FN}, TP={TP} ")
```

```
print(f"--------")
print(f"matriz de confusion %:")
total1=(TN+TP+FN+FP)

print(f"TN={100*TN/total1}, FP={100*FP/total1} ")
print(f"FN={100*FN/total1}, TP={100*TP/total1} ")

print(f"--------")
acc1=(TN+TP)/(TN+TP+FN+FP)
print(f"accuracy1={acc1}")

print(f"--------")
re1=(TP)/(TP+FN)
print(f"reca1={re1}")

print(f"--------")
pre1=(TP)/(TP+FP)
print(f"pre1={pre1}")

print(f"--------")
f1s1=(2*pre1*re1)/(pre1+re1)
print(f"f1score={f1s1}")
```

```
[[2792    0]
 [   0 2809]]
multi_metric_scores:
{'fit_time': array([13.70309615, 13.68394828, 13.90837884, 13.79051661, 13.67019773,
       14.14955759, 14.21738338, 14.35204458, 14.29634309, 13.40078807]), 'score_time':
       0.11818528, 0.12190866, 0.12092113, 0.12525129, 0.11808348]), 'test_accuracy': ar
       1.        , 1.        , 1.        , 1.        , 0.82964286]), 'test_f1': array([0
       1.        , 1.        , 1.        , 1.        , 0.85426214]), 'test_recall': arra
       1.        , 1.        , 1.        , 1.        , 0.99857143]), 'test_precision': a
       1.        , 1.        , 1.        , 1.        , 0.74639616])}
Training time: 295.0970540046692s
[[2792    0]
 [   0 2809]]
              precision    recall  f1-score   support

           0       1.00      1.00      1.00      2792
           1       1.00      1.00      1.00      2809

    accuracy                           1.00      5601
   macro avg       1.00      1.00      1.00      5601
weighted avg       1.00      1.00      1.00      5601
```




```
accuracy:
```

```
import joblib
from sklearn.ensemble import RandomForestClassifier
# create RF
```

```
 1          1          1          0.74639616]
```

```
# save
joblib.dump(clf, "my_random_forest.joblib")
```

```
['my_random_forest.joblib']

f1:
```

```
# load
loaded_rf = joblib.load("my_random_forest.joblib")
```

```
--------
```

```
#predicciones
#clf.predict([[0.0,53.55902,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0]])
```

```
#predicciones
loaded_rf.predict([[0.0,53.55902,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0]])
```

```
array([1])
```

```
# 1 es recovering
loaded_rf.predict([[0.0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0]])
```

```
array([1])

f1score=1.0
```

```
# 0 es recovering
loaded_rf.predict([[2.465394,47.092009999999995,53.2118,46.310759999999995,634375,47.52422,41
```

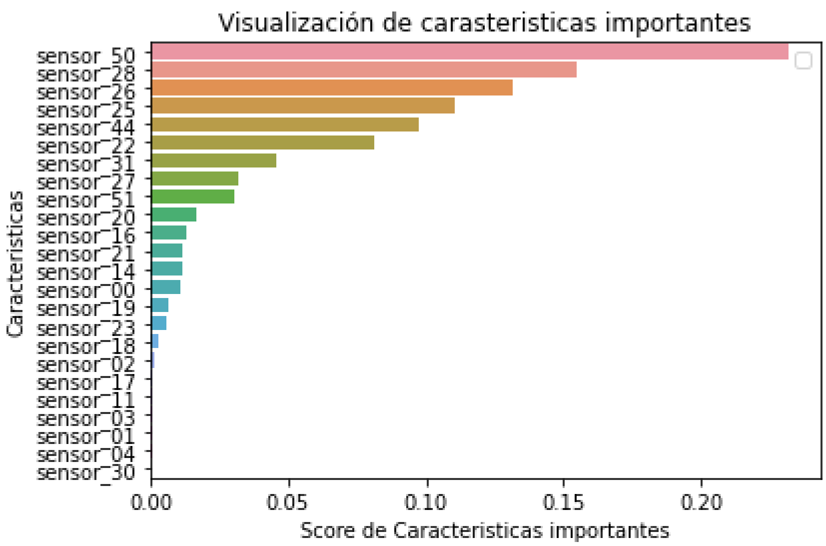
```
array([1])
```

```
# 2 es broken
loaded_rf.predict([[2.258796,47.26563,52.73437,43.4461784362793,200.11573791503898,43.62322,4
```

```
array([1])
```

```
# https://seaborn.pydata.org/generated/seaborn.barplot.html

import pandas as pd
#feature_imp = pd.Series(clf.feature_importances_,index=iris.feature_names).sort_values(ascen
#feature_imp = pd.Series(clf.feature_importances_,index=X.columns[1:8]).sort_values(ascending
feature_imp = pd.Series(clf.feature_importances_,index=X.columns[0:24]).sort_values(ascending
print(feature_imp)

#Visualización
import matplotlib.pyplot as plt
import seaborn as sns
%matplotlib inline
# Creating a bar plot
sns.barplot(x=feature_imp, y=feature_imp.index)
# Add labels to your graph
#plt.xlabel('Feature Importance Score')
plt.xlabel('Score de Caracteristicas importantes')
#plt.ylabel('Features')
plt.ylabel('Caracteristicas')
#plt.title("Visualizing Important Features")
plt.title("Visualización de carasteristicas importantes")
plt.legend()
plt.show()

#plt.savefig('destination_path.eps', format='eps' , dpi=1000)

plt.savefig('myimage.svg', format='svg', dpi=1200)
```

```
No handles with labels found to put in legend.
sensor_50    0.232008614527387
sensor_28    0.155139301713169
sensor_26    0.131795898646431
sensor_25    0.110861851269088
sensor_44    0.097505361456306
sensor_22    0.081278757345340
sensor_31    0.045465172383412
sensor_27    0.031709722277840
sensor_51    0.030814483227659
sensor_20    0.016924944332720
sensor_16    0.013014833663071
sensor_21    0.011633081219379
sensor_14    0.011314503461296
sensor_00    0.010804480943123
sensor_19    0.006824543819885
sensor_23    0.005805154043774
sensor_18    0.003030557161612
sensor_02    0.001205321192704
sensor_17    0.000589871703175
sensor_11    0.000555745724755
sensor_03    0.000537576783007
sensor_01    0.000515291133954
sensor_04    0.000410336591203
sensor_30    0.000254595379709
dtype: float64
```




```
# https://towardsdatascience.com/how-to-visualize-a-decision-tree-from-a-random-forest-in-pyt
```