```
# gerardo Herrera... random forest (25 arboles) con 28k instacias de normal y recovering y 24
```

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

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

```
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 (2.2.3
     Requirement already satisfied: scikit-learn in /usr/local/lib/python3.6/dist-packages (f
     Requirement already satisfied: scipy in /usr/local/lib/python3.6/dist-packages (from lig
     Requirement already satisfied: numpy in /usr/local/lib/python3.6/dist-packages (from lig
     Requirement already satisfied: joblib>=0.11 in /usr/local/lib/python3.6/dist-packages (f
     Collecting catboost
       Downloading https://files.pythonhosted.org/packages/52/39/128fff65072c8327371e3c594f3
          |████████████████████████████████| 66.2MB 56kB/s
     Requirement already satisfied: six in /usr/local/lib/python3.6/dist-packages (from catbo
     Requirement already satisfied: scipy in /usr/local/lib/python3.6/dist-packages (from cat
     Requirement already satisfied: numpy>=1.16.0 in /usr/local/lib/python3.6/dist-packages (
     Requirement already satisfied: graphviz in /usr/local/lib/python3.6/dist-packages (from
     Requirement already satisfied: pandas>=0.24.0 in /usr/local/lib/python3.6/dist-packages
     Requirement already satisfied: matplotlib in /usr/local/lib/python3.6/dist-packages (fro
     Requirement already satisfied: plotly in /usr/local/lib/python3.6/dist-packages (from ca
     Requirement already satisfied: pytz>=2017.2 in /usr/local/lib/python3.6/dist-packages (f
     Requirement already satisfied: python-dateutil>=2.7.3 in /usr/local/lib/python3.6/dist-p
     Requirement already satisfied: kiwisolver>=1.0.1 in /usr/local/lib/python3.6/dist-packag
     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: retrying>=1.3.3 in /usr/local/lib/python3.6/dist-packages
     Installing collected packages: catboost
     Successfully installed catboost-0.24.2
```

```
# 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()
```

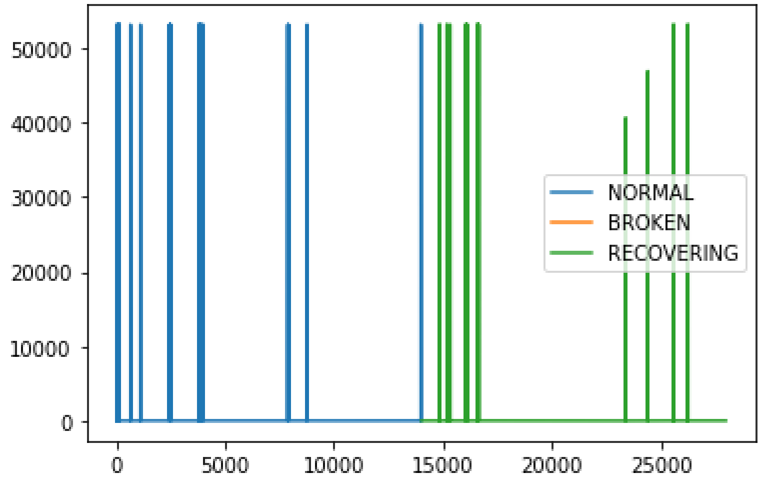
```
        Unnamed:  timestamp  sensor_00          sensor_01           sensor_02          sens
```

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

```
      0         0         01    2.465394   47.092010000000002   53.211799999999997   46.3107600000
```

```
# 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 0x7f759062b438>
```



```
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())
```

21	21	[illegible]	[illegible]	[illegible]	[illegible]

```
# 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=25)

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: 0.7204201221466064s
    Accuracy: 0.9998214604534904
    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])
```

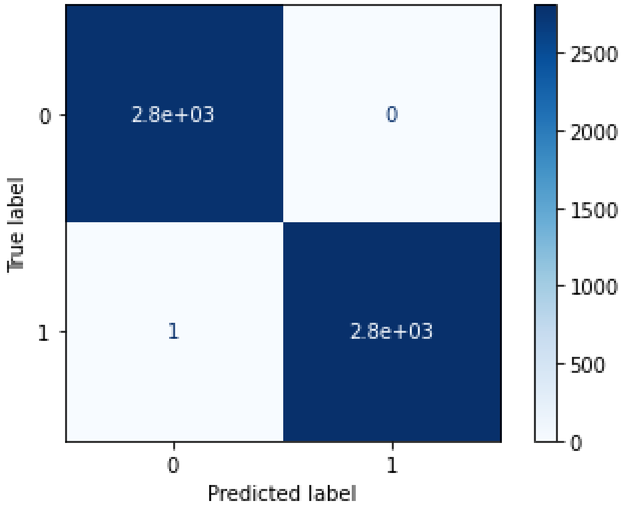
```
#predicciones
clf.predict([[0.0,53.55902,52.77777,43.402774810790994,204.72509765625,3.7302410000000004,404
```

```
    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: 30.822885751724243s


#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=25)

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()
```

```
[[2789    0]
 [   1 2811]]
[0.99107462 0.99964298 1.         1.         0.99892857 1.
 1.         1.         1.         0.85535714]
0.9845003315142551
Training time: 7.9669787883758545s
[[2789    0]
 [   1 2811]]
              precision    recall  f1-score   support

           0       1.00      1.00      1.00      2789
           1       1.00      1.00      1.00      2812

    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 scroring
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=25)

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()
```

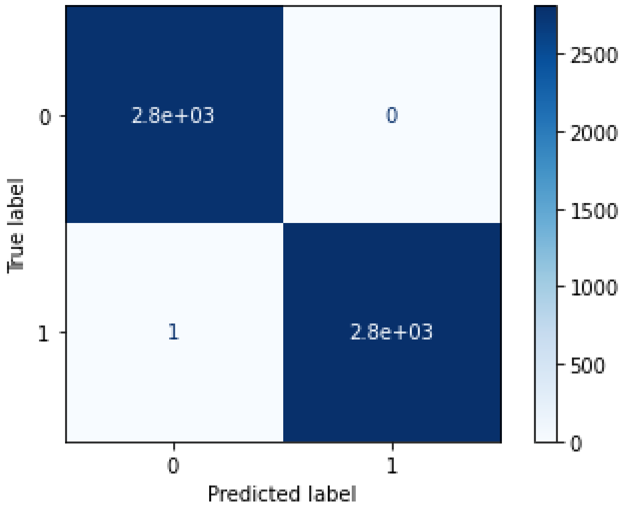
```
[[2789    0]
 [   1 2811]]
precision_macro_score:
[0.99680851 0.99964311 1.         0.99751244 1.         1.
 1.         1.         1.         0.92250945]
0.9916473508329371
test_score:
[0.99714388 0.99964298 1.         1.         1.         1.
 1.         1.         1.         0.79071429]
0.9787501147549345
```

```
# 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=25)

#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}")
```

```
[[2789    0]
 [   1 2811]]
multi_metric_scores:
{'fit_time': array([0.68429852, 0.75059485, 0.79937196, 0.81243873, 0.76197147,
       0.78753948, 0.76873612, 0.80026364, 0.79576921, 0.83706284]), 'score_time': array
       0.01073599, 0.01081562, 0.01152539, 0.01071858, 0.01142955]), 'test_accuracy': ar
       1.        , 1.        , 1.        , 1.        , 0.79464286]), 'test_f1': array([
       1.        , 1.        , 1.        , 1.        , 0.82952861]), 'test_recall': arra
       1.        , 1.        , 1.        , 1.        , 0.99928571]), 'test_precision': a
       1.        , 1.        , 1.        , 1.        , 0.70907248])}
Training time: 16.54348850250244s
[[2789    0]
 [   1 2811]]
              precision    recall  f1-score   support

           0       1.00      1.00      1.00      2789
           1       1.00      1.00      1.00      2812

    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.          [illegible] 1.          1.
 1.          1.          1.          0.70907248]
```

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

```
['my_random_forest.joblib']

f1:
```

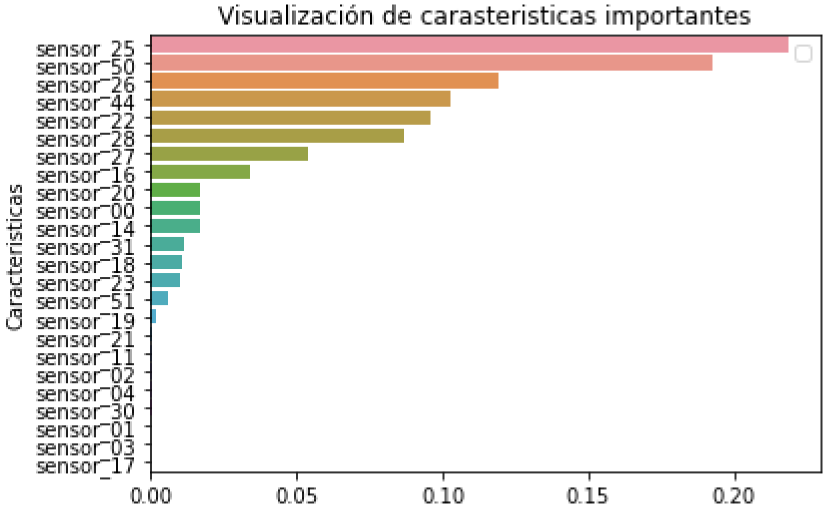
```
# load
loaded_rf = joblib.load("my_random_forest.joblib")
```

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

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

```
#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]])

     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]])

     array([1])

# 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])



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)
```

```
sensor_25    0.218585577489896
sensor_50    0.192494505492431
sensor_26    0.118933369964408
sensor_44    0.103024605453617
sensor_22    0.095838605122650
sensor_28    0.086903813644770
sensor_27    0.054355455121461
sensor_16    0.034016238185235
sensor_20    0.017186116553708
sensor_00    0.017118197083998
sensor_14    0.017109034806036
sensor_31    0.011367880294808
sensor_18    0.010654964736604
sensor_23    0.010360987502906
sensor_51    0.006311624990248
sensor_19    0.002119835128739
sensor_21    0.000733754684364
sensor_11    0.000626502174069
sensor_02    0.000602177105466
sensor_04    0.000544201099041
sensor_30    0.000456629591572
sensor_01    0.000279868153119
sensor_03    0.000258636462968
sensor_17    0.000117419157886
dtype: float64
No handles with labels found to put in legend.
```



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