Projeto Final

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1 Bibliotecas Usadas

[ ]:
```
import pandas as pd
import os
from os.path import exists
from os import environ
environ['TF_CPP_MIN_LOG_LEVEL'] = '3'

import numpy as np
import pandas as pd
import pickle

from keras.wrappers.scikit_learn import KerasClassifier
from sklearn.svm import SVC
from sklearn.ensemble import GradientBoostingClassifier,␣
↪RandomForestClassifier, VotingClassifier
from sklearn.neural_network import MLPClassifier
```

[ ]:
```
# from google.colab import drive
# drive.mount('/content/drive')
# !pip install scikit-plot
# !python /content/drive/MyDrive/neural-networks/project_metrics/
↪project_metrics.py
```

2 Separando os Dados

[ ]:
```
DATASET_EXISTS = exists("TRNcod.xls")
```

2.1 Carregando o Dataset

[ ]:
```
if DATASET_EXISTS:
    df = pd.read_csv("TRNcod.xls",sep="\t")
    print(f"DATAFRAME SIZE: {len(df)}")
```

[ ]:
```
if DATASET_EXISTS:
    df.describe()
```

[ ]:
```
if DATASET_EXISTS:
    df.head()
```

[ ]:
```
if DATASET_EXISTS:
    df.tail()
```

2.2 Separando o Dataframe em Classes

[ ]:
```
if DATASET_EXISTS:
    df_1_1=df[df["IND_BOM_1_1"]==1]
    df_1_2=df[df["IND_BOM_1_2"]==1]
    print("DATAFRAME SIZE:")
    print(f"IND_BOM_1_1: {len(df_1_1)}")
    print(f"IND_BOM_1_2: {len(df_1_2)}")
```

2.3 Aleatorizando o Dataframe

[ ]:
```
if DATASET_EXISTS:
    df_1_1=df_1_1.sample(frac=1, random_state=1).reset_index(drop=True)
    df_1_2=df_1_2.sample(frac=1, random_state=1).reset_index(drop=True)
```

2.4 Separando os Dados em Treino validação e teste

2.4.1 IND_BOM_1_1

[ ]:
```
if DATASET_EXISTS:
    df_1_1_train = df_1_1.sample(frac=0.5)
    df_1_1 = df_1_1.drop(df_1_1_train.index)
    df_1_1_val = df_1_1.sample(frac=0.5)
    df_1_1_test = df_1_1.drop(df_1_1_val.index)

    df_1_1_train = df_1_1_train.reset_index(drop=True)
    df_1_1_val = df_1_1_val.reset_index(drop=True)
    df_1_1_test = df_1_1_test.reset_index(drop=True)

    print("DATAFRAME SIZE:")
    print(f"TRAIN DATA: {len(df_1_1_train)}")
    print(f"VALIDATION DATA: {len(df_1_1_val)}")
```

```
    print(f"TEST DATA: {len(df_1_1_test)}")
```

2.4.2 IND_BOM_1_2

[ ]:
```
if DATASET_EXISTS:
    df_1_2_train = df_1_2.sample(frac=0.5)
    df_1_2 = df_1_2.drop(df_1_2_train.index)
    df_1_2_val = df_1_2.sample(frac=0.5)
    df_1_2_test = df_1_2.drop(df_1_2_val.index)

    df_1_2_train = df_1_2_train.reset_index(drop=True)
    df_1_2_val = df_1_2_val.reset_index(drop=True)
    df_1_2_test = df_1_2_test.reset_index(drop=True)

    print("DATAFRAME SIZE:")
    print(f"TRAIN DATA: {len(df_1_2_train)}")
    print(f"VALIDATION DATA: {len(df_1_2_val)}")
    print(f"TEST DATA: {len(df_1_2_test)}")
```

2.5 Concatenando o Dataset com a Classe Minoritária com Suas Primeiras Linhas

[ ]:
```
if DATASET_EXISTS:
    df_1_2_train = pd.concat((df_1_2_train, df_1_2_train.iloc[:
 ↪len(df_1_1_train)-len(df_1_2_train)]), axis = 0)
    df_1_2_val = pd.concat((df_1_2_val, df_1_2_val.iloc[:
 ↪len(df_1_1_val)-len(df_1_2_val)]), axis = 0)

    print("DATAFRAME SIZE:")
    print(f"TRAIN DATA: {len(df_1_2_train)}")
    print(f"VALIDATION DATA: {len(df_1_2_val)}")
    print(f"TEST DATA: {len(df_1_2_test)}")
```

2.6 Juntando os Datasets Contendo Ambas as Classes

[ ]:
```
if DATASET_EXISTS:
    train_data = pd.concat((df_1_1_train, df_1_2_train), axis = 0)
    val_data = pd.concat((df_1_1_val, df_1_2_val), axis = 0)
    test_data = pd.concat((df_1_1_test, df_1_2_test), axis = 0)

    train_data = train_data.sample(frac=1, random_state=1).
 ↪reset_index(drop=True)
    val_data = val_data.sample(frac=1, random_state=1).reset_index(drop=True)
    test_data = test_data.sample(frac=1, random_state=1).reset_index(drop=True)

    print("DATAFRAME SIZE:")
```

```
    print(f"TRAIN DATA: {len(train_data)}")
    print(f"VALIDATION DATA: {len(val_data)}")
    print(f"TEST DATA: {len(test_data)}")
```

2.7 Checando se Os Passos Foram Executados Corretamente

2.7.1 Checando por Interseção Entre os Dados

[ ]:
```
if DATASET_EXISTS:
    train_index = set(train_data["INDEX"])
    val_index = set(val_data["INDEX"])
    test_index = set(test_data["INDEX"])

    print("DATAFRAME SIZE:")
    print(f"TRAIN DATA: {len(df_1_2_train)}")
    print(f"VALIDATION DATA: {len(df_1_2_val)}")
    print(f"TEST DATA: {len(df_1_2_test)}")
```

[ ]:
```
if DATASET_EXISTS:
    train_val_intersection = train_index.intersection(val_index)
    train_test_intersection = train_index.intersection(test_index)
    val_test_intersection = val_index.intersection(test_index)

    assert not train_val_intersection, f"Intersection {train_val_intersection}␣
 ↪found between train and validation datasets!"
    assert not train_test_intersection, f"Intersection␣
 ↪{train_test_intersection} found between train and test datasets!"
    assert not train_test_intersection, f"Intersection {val_test_intersection}␣
 ↪found between validation and test datasets!"
```

2.7.2 Checando se Ambas as Classes Possuem a Mesma Quantidade de Dados

[ ]:
```
if DATASET_EXISTS:
    assert len(train_data[train_data["IND_BOM_1_1"]==1]) ==␣
 ↪len(train_data[train_data["IND_BOM_1_2"]==1]), "Train data classes have␣
 ↪mismatching sizes!"
    assert len(val_data[val_data["IND_BOM_1_1"]==1]) ==␣
 ↪len(val_data[val_data["IND_BOM_1_2"]==1]), "Validation data classes have␣
 ↪mismatching sizes!"
```

2.8 Salvando Dados para Arquivo CSV

[ ]:
```
ASSETS_FOLDER = "Assets"
TRAIN_DATA_CSV = f"{ASSETS_FOLDER}/train.csv"
VAL_DATA_CSV = f"{ASSETS_FOLDER}/val.csv"
TEST_DATA_CSV = f"{ASSETS_FOLDER}/train.csv"
```

```
if not (exists(TRAIN_DATA_CSV) and exists(VAL_DATA_CSV) and␣
 ↪exists(TEST_DATA_CSV)):
    train_data.to_csv(TRAIN_DATA_CSV)
    val_data.to_csv(VAL_DATA_CSV)
    test_data.to_csv(TEST_DATA_CSV)
```

3 Carregando os dados que Foram Previamente Separados

[ ]:
```
df_train = pd.read_csv("Assets/train.csv")
df_val= pd.read_csv("Assets/val.csv")
df_test = pd.read_csv("Assets/test.csv")

# df_train = pd.read_csv("/content/drive/MyDrive/neural-networks/Assets/train.
 ↪csv")
# df_val= pd.read_csv("/content/drive/MyDrive/neural-networks/Assets/val.csv")
# df_test = pd.read_csv("/content/drive/MyDrive/neural-networks/Assets/test.
 ↪csv")

df_train.drop("INDEX", inplace=True, axis =1)
df_val.drop("INDEX", inplace=True, axis =1)
df_test.drop("INDEX", inplace=True, axis =1)

df_train.drop("Unnamed: 0", inplace=True, axis =1)
df_val.drop("Unnamed: 0", inplace=True, axis =1)
df_test.drop("Unnamed: 0", inplace=True, axis =1)

df_train.drop("IND_BOM_1_2", inplace=True, axis =1)
df_val.drop("IND_BOM_1_2", inplace=True, axis =1)
df_test.drop("IND_BOM_1_2", inplace=True, axis =1)

y_train = df_train["IND_BOM_1_1"].values
y_val = df_val["IND_BOM_1_1"].values
y_test = df_test["IND_BOM_1_1"].values

df_train.drop("IND_BOM_1_1", inplace=True, axis =1)
df_val.drop("IND_BOM_1_1", inplace=True, axis =1)
df_test.drop("IND_BOM_1_1", inplace=True, axis =1)

x_train = df_train.values
x_val = df_val.values
x_test = df_test.values

x_train.shape
```

[ ]:
```
(255098, 243)
```

4 Métricas

[ ]:
```
from sklearn.metrics import accuracy_score, recall_score, precision_score,␣
 ↪f1_score
from sklearn.metrics import confusion_matrix, classification_report
from sklearn.metrics import roc_auc_score, average_precision_score
from keras.callbacks import History

import scikitplot as skplt
import matplotlib.pyplot as plt
import seaborn as sns
import numpy as np

CLASSES = ["0", "1"]

# Essas funções foram baseadas em: https://github.com/RomeroBarata/
 ↪IF702-redes-neurais/blob/master/main.ipynb
class Metrics():
    def extract_final_losses(self,history:dict):
        """Função para extrair o melhor loss de treino e validação.

        Argumento(s):
        history -- Objeto retornado pela função fit do keras.

        Retorno:
        Dicionário contendo o melhor loss de treino e de validação baseado
        no menor loss de validação.
        """
        train_loss = history['loss']
        val_loss = history['val_loss']
        idx_min_val_loss = np.argmin(val_loss)
        return {'train_loss': train_loss[idx_min_val_loss], 'val_loss':␣
 ↪val_loss[idx_min_val_loss]}

    def plot_training_error_curves(self, history:History):
        """Função para plotar as curvas de erro do treinamento da rede neural.

        Argumento(s):
        history -- Objeto retornado pela função fit do keras.

        Retorno:
        A função gera o gráfico do treino da rede e retorna None.
        """
        train_loss = history['loss']
        val_loss = history['val_loss']

        fig, ax = plt.subplots()
```

```
        ax.plot(train_loss, label='Train')
        ax.plot(val_loss, label='Validation')
        ax.set(title='Training and Validation Error Curves', xlabel='Epochs',␣
↪ylabel='Loss (MSE)')
        ax.legend()
        plt.show()

    def compute_performance_metrics(self, y, y_pred_class, y_pred_scores=None):
        accuracy = accuracy_score(y, y_pred_class)
        recall = recall_score(y, y_pred_class)
        precision = precision_score(y, y_pred_class)
        f1 = f1_score(y, y_pred_class)
        performance_metrics = (accuracy, recall, precision, f1)
        if y_pred_scores is not None:
            skplt.metrics.plot_ks_statistic(y, y_pred_scores)
            plt.show()
            y_pred_scores = y_pred_scores[:, 1]
            auroc = roc_auc_score(y, y_pred_scores)
            aupr = average_precision_score(y, y_pred_scores)
            performance_metrics = performance_metrics + (auroc, aupr)
        return performance_metrics

    def print_metrics_summary(self, accuracy, recall, precision, f1,␣
↪auroc=None, aupr=None):
        print()
        print("{metric:<18}{value:.4f}".format(metric="Accuracy:",␣
↪value=accuracy))
        print("{metric:<18}{value:.4f}".format(metric="Recall:", value=recall))
        print("{metric:<18}{value:.4f}".format(metric="Precision:",␣
↪value=precision))
        print("{metric:<18}{value:.4f}".format(metric="F1:", value=f1))
        if auroc is not None:
            print("{metric:<18}{value:.4f}".format(metric="AUROC:",␣
↪value=auroc))
        if aupr is not None:
            print("{metric:<18}{value:.4f}".format(metric="AUPR:", value=aupr))


    # def get_data(network, test_data):
    #     results = [(np.argmax(network.feedforward(x)), y) for (x, y) in␣
↪test_data]
    #     y_true = [i for i,_ in results]
    #     y_pred = [j for _,j in results]
    #     return y_true,y_pred
```

```
    def plot_confusion_matrix(self, y_true, y_pred, fontsize = 20):
        """
        This function was based on https://medium.com/@dtuk81/
↪confusion-matrix-visualization-fc31e3f30fea
        """
        #y_true,y_pred = get_data(network, test_data)
        cf_matrix = confusion_matrix(y_true,y_pred)
        group_names = ["True Neg","False Pos","False Neg","True Pos"]
        group_counts = ["{0:0.0f}".format(value) for value in cf_matrix.
↪flatten()]
        group_percentages = ["{0:.2%}".format(value) for value in cf_matrix.
↪flatten()/np.sum(cf_matrix)]
        labels = [f"{v1}\n{v2}\n{v3}" for v1, v2, v3 in␣
↪zip(group_names,group_counts,group_percentages)]
        labels = np.asarray(labels).reshape(2,2)
        s = sns.heatmap(cf_matrix, annot=labels, fmt="")
        # plt.figure(figsize = figsize)
        # plt.title(title,fontsize = fontsize + int(0.5*fontsize))
        # s = sns.heatmap(cm, annot = True, xticklabels = classes, yticklabels␣
↪= classes,fmt = fmt)
        s.set_xlabel('Predicted Label',fontsize = fontsize)
        s.set_ylabel('True Label', fontsize = fontsize)
        #plt.show()

    def print_classification_report(self, y_true,y_pred, classes=CLASSES):
        # y_true,y_pred = get_data(network, test_data)
        print(classification_report(y_true,y_pred,target_names=classes))

metrics = Metrics()
```

5 Algoritmos de Aprendizado de Máquina

5.1 MLP

[ ]:
```
from keras.models import Sequential
from keras.layers import Dense
from keras.callbacks import EarlyStopping
import keras

MODELS_PATH = "Models/MLP"
HISTORY_PATH = f"{MODELS_PATH}/history"
MODEL_PATH = f"{MODELS_PATH}/model"
```

5.1.1 Experimento1

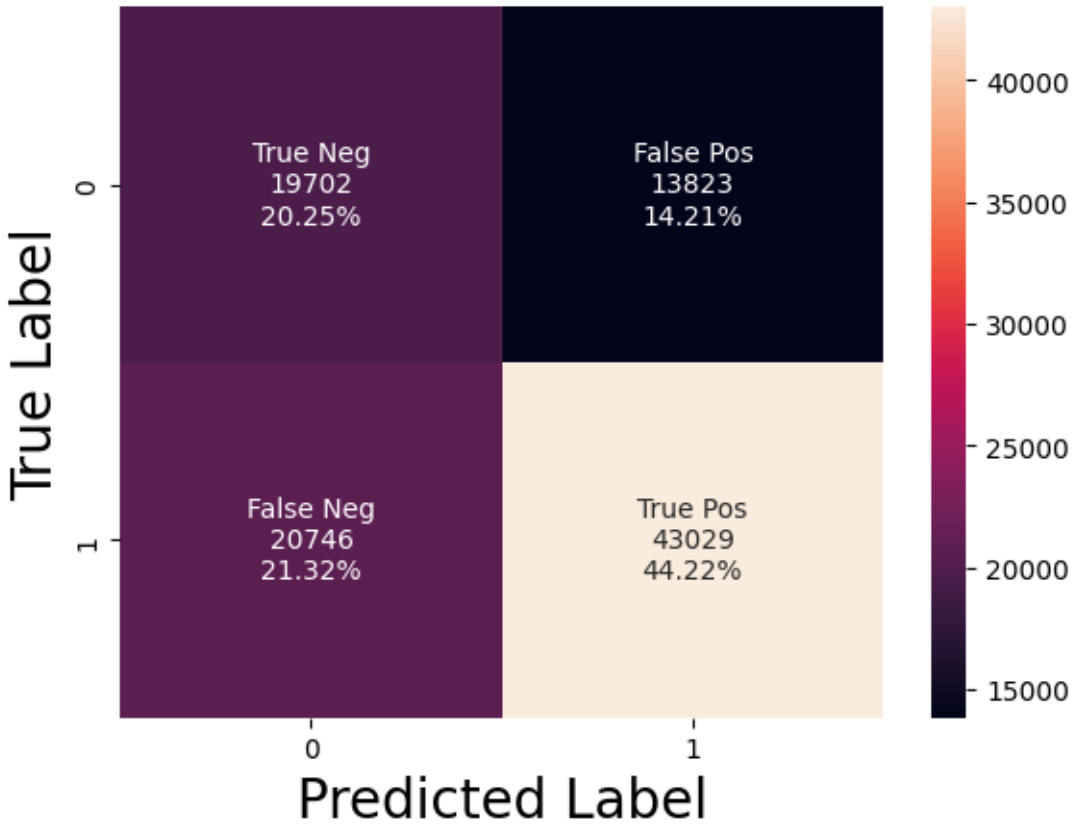
[ ]:
```
input_dim = x_train.shape[1]

classifier = Sequential()

classifier.add(Dense(16, activation='relu', input_dim=input_dim))
classifier.add(Dense(1, activation='sigmoid'))
classifier.compile(optimizer='adam', loss='mean_squared_error')

history_file = HISTORY_PATH + "1.npy"
model_file = MODEL_PATH + "1"

if not exists(history_file) or  not exists(model_file):
    history = classifier.fit(x_train, y_train, batch_size=32, epochs=10_000,␣
 ↪callbacks=[EarlyStopping(patience=10,verbose=1)], validation_data=(x_val,␣
 ↪y_val))
    np.save(history_file,history.history)
    classifier.save(model_file)
else:
    print("Model was already trained")

history=np.load(history_file, allow_pickle='TRUE').item()
classifier = keras.models.load_model(model_file)
```

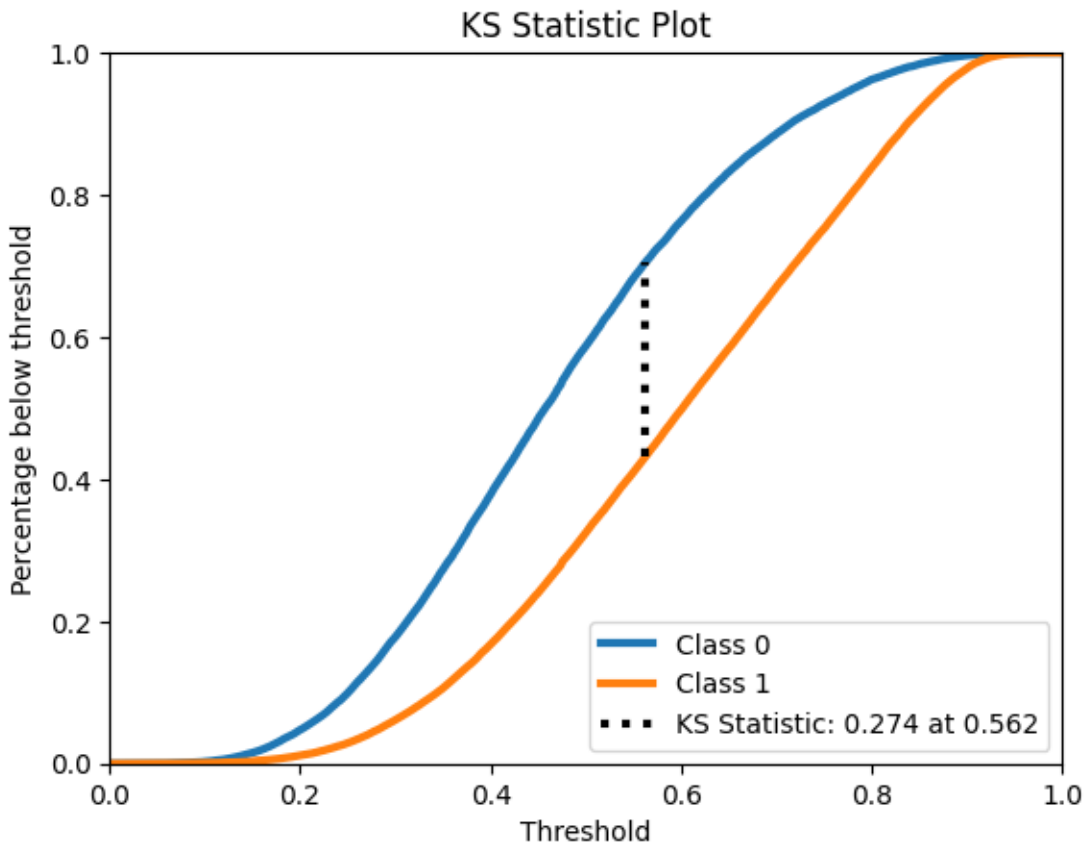
```
Model was already trained
```

[ ]:
```
# Fazer predições no conjunto de teste
y_pred_scores = classifier.predict(x_test)
y_pred_class = (y_pred_scores > 0.5).astype("int32")
y_pred_scores_0 = 1 - y_pred_scores
y_pred_scores = np.concatenate([y_pred_scores_0, y_pred_scores], axis=1)

## Matriz de confusão
print('Matriz de confusão no conjunto de teste:')
metrics.plot_confusion_matrix(y_test, y_pred_class)

## Resumo dos resultados
losses = metrics.extract_final_losses(history)
print()
print("{metric:<18}{value:.4f}".format(metric="Train Loss:",␣
 ↪value=losses['train_loss']))
print("{metric:<18}{value:.4f}".format(metric="Validation Loss:",␣
 ↪value=losses['val_loss']))
print('\nPerformance no conjunto de teste:')
accuracy, recall, precision, f1, auroc, aupr = metrics.
 ↪compute_performance_metrics(y_test, y_pred_class, y_pred_scores)
```

```
metrics.print_metrics_summary(accuracy, recall, precision, f1, auroc, aupr)
```

```
3041/3041 [==============================] - 2s 650us/step
Matriz de confusão no conjunto de teste:

Train Loss:       0.2187
Validation Loss:  0.2214

Performance no conjunto de teste:
```






```
Accuracy:           0.6447
Recall:             0.6747
Precision:          0.7569
F1:                 0.7134
AUROC:              0.6887
AUPR:               0.8014
```

5.1.2 Experimento2

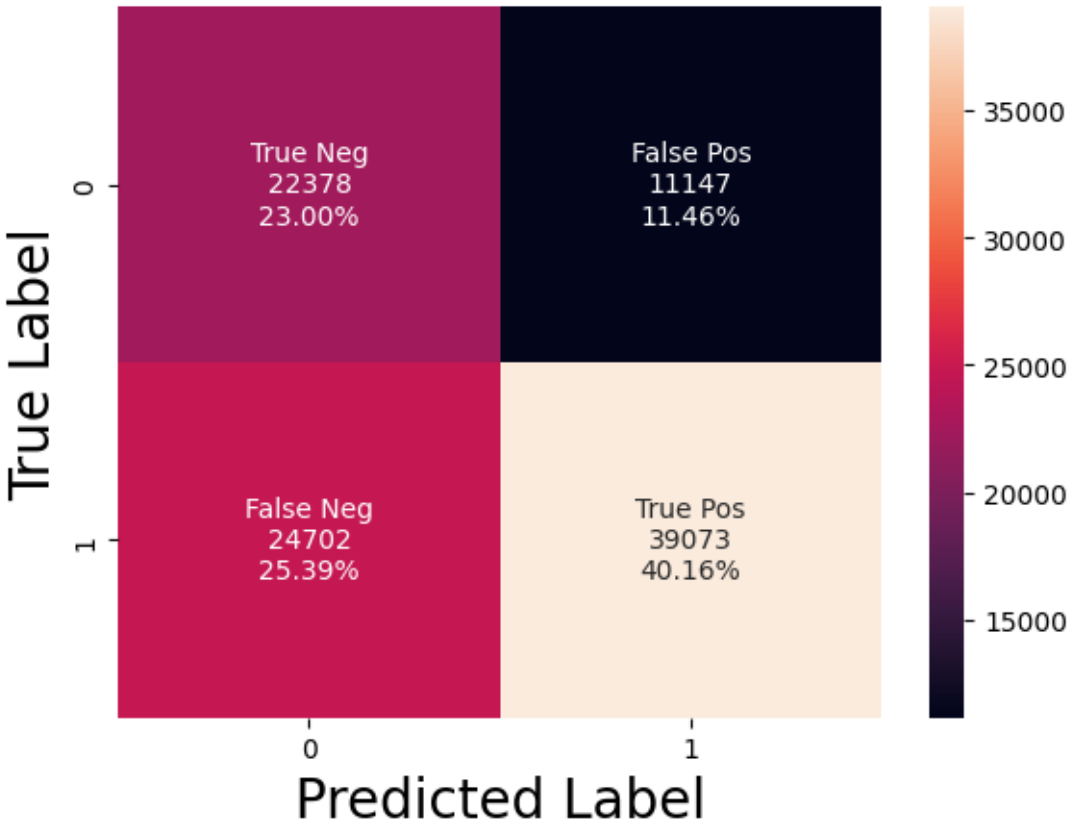
[ ]:
```
# Número de features do nosso data set.
input_dim = x_train.shape[1]

# Aqui criamos o esboço da rede.
classifier = Sequential()

classifier.add(Dense(256, activation='relu', input_dim=input_dim))
classifier.add(Dense(128, activation='relu', input_dim=input_dim))
classifier.add(Dense(1, activation='sigmoid'))
classifier.compile(optimizer='adam', loss='mean_squared_error')
```

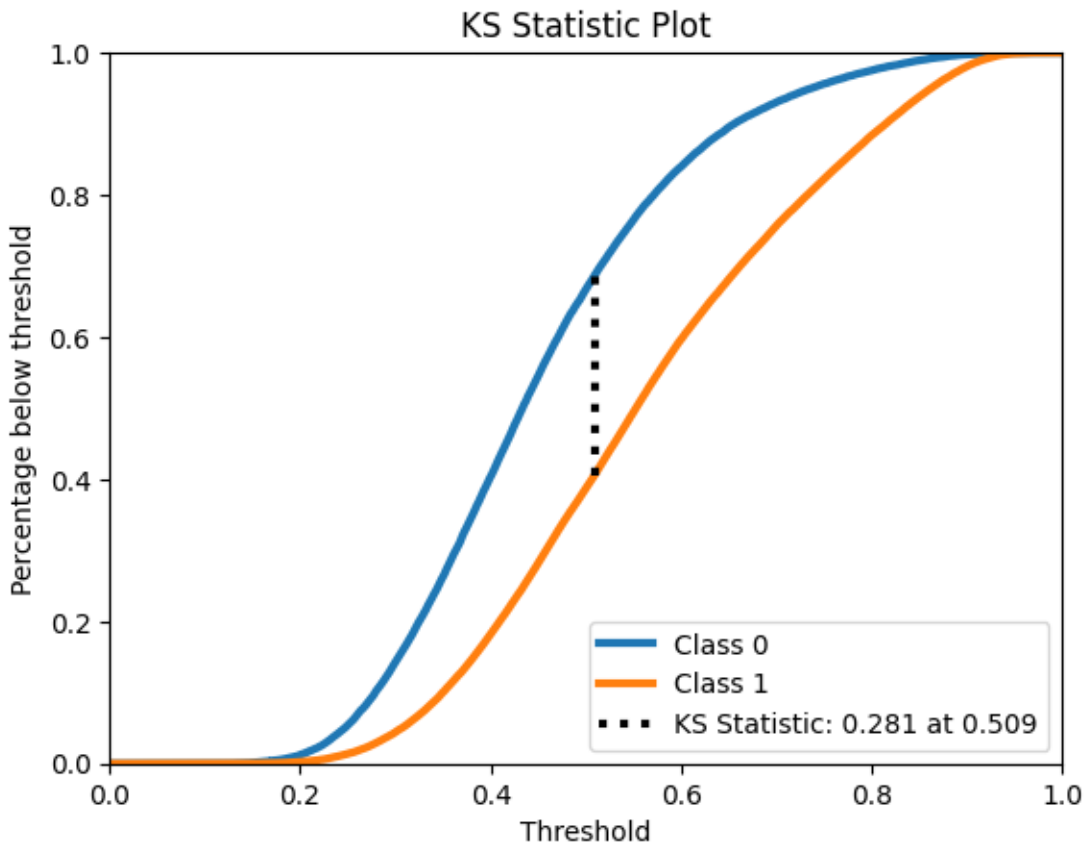
```
history_file = HISTORY_PATH + "2.npy"
model_file = MODEL_PATH + "2"

if not exists(history_file) or  not exists(model_file):
    history = classifier.fit(x_train, y_train, batch_size=32, epochs=10_000,␣
 ↪callbacks=[EarlyStopping(patience=20,verbose=1,restore_best_weights=True)],␣
 ↪validation_data=(x_val, y_val))
    np.save(history_file,history.history)
    classifier.save(model_file)
else:
    print("Model was already trained")

history=np.load(history_file, allow_pickle='TRUE').item()
classifier = keras.models.load_model(model_file)
```

```
Model was already trained
```

[ ]:
```
# Fazer predições no conjunto de teste
y_pred_scores = classifier.predict(x_test)
y_pred_class = (y_pred_scores > 0.5).astype("int32")
y_pred_scores_0 = 1 - y_pred_scores
y_pred_scores = np.concatenate([y_pred_scores_0, y_pred_scores], axis=1)

## Matriz de confusão
print('Matriz de confusão no conjunto de teste:')
metrics.plot_confusion_matrix(y_test, y_pred_class)

## Resumo dos resultados
losses = metrics.extract_final_losses(history)
print()
print("{metric:<18}{value:.4f}".format(metric="Train Loss:",␣
 ↪value=losses['train_loss']))
print("{metric:<18}{value:.4f}".format(metric="Validation Loss:",␣
 ↪value=losses['val_loss']))
print('\nPerformance no conjunto de teste:')
accuracy, recall, precision, f1, auroc, aupr = metrics.
 ↪compute_performance_metrics(y_test, y_pred_class, y_pred_scores)
metrics.print_metrics_summary(accuracy, recall, precision, f1, auroc, aupr)
```

```
3041/3041 [==============================] - 3s 849us/step
Matriz de confusão no conjunto de teste:

Train Loss:       0.2206
Validation Loss:  0.2213

Performance no conjunto de teste:
```


True Neg
22378
23.00%
False Pos
11147
11.46%
False Neg
24702
25.39%
True Pos
39073
40.16%
True Label
Predicted Label
0
1
0
1
35000
30000
25000
20000
15000




```
Accuracy:           0.6316
Recall:             0.6127
Precision:          0.7780
F1:                 0.6855
AUROC:              0.6921
AUPR:               0.8042
```

5.1.3 Experimento3

[ ]:
```
# Número de features do nosso data set.
input_dim = x_train.shape[1]

# Aqui criamos o esboço da rede.
classifier = Sequential()

classifier.add(Dense(512, activation='sigmoid', input_dim=input_dim))
classifier.add(Dense(256, activation='sigmoid', input_dim=input_dim))
classifier.add(Dense(1, activation='sigmoid'))
```

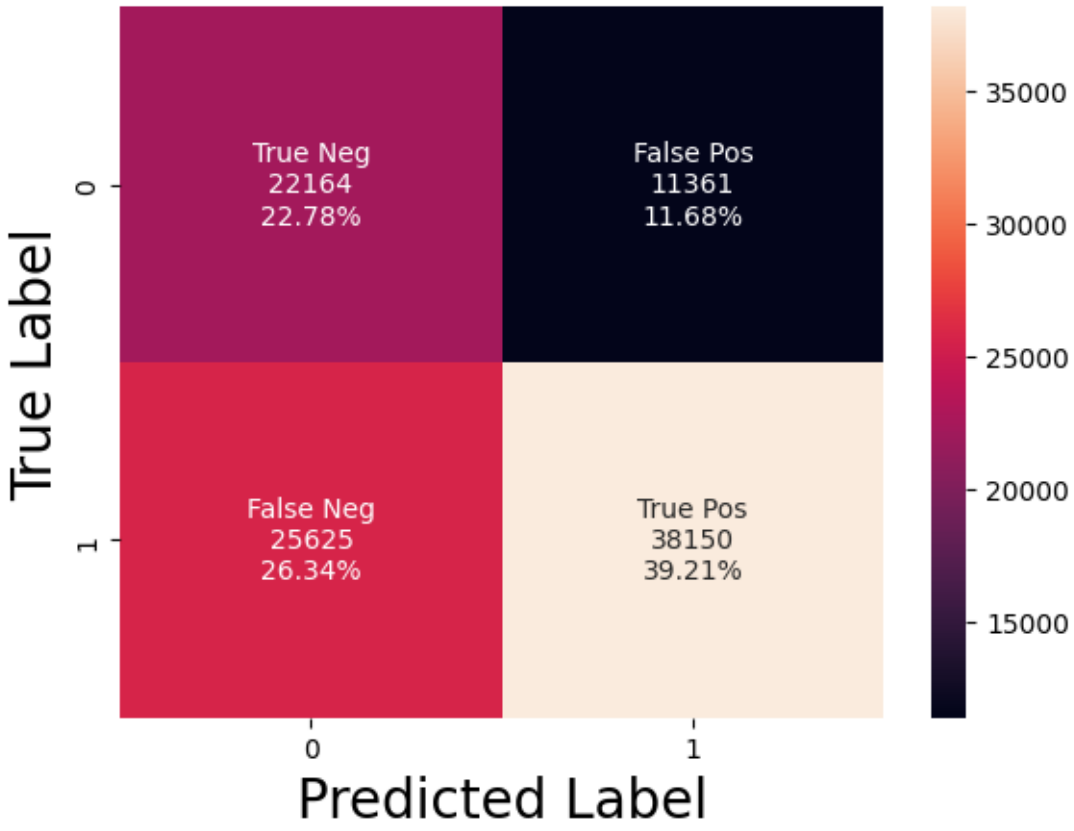
```
optimizer=keras.optimizers.SGD( learning_rate=0.01)
classifier.compile(optimizer=optimizer, loss='mean_squared_error')

history_file = HISTORY_PATH + "3.npy"
model_file = MODEL_PATH + "3"

if not exists(history_file) or  not exists(model_file):
    history = classifier.fit(x_train, y_train, batch_size=32, epochs=1_000,␣
 ↪callbacks=[EarlyStopping(patience=20,verbose=1,restore_best_weights=True)],␣
 ↪validation_data=(x_val, y_val))
    np.save(history_file,history.history)
    classifier.save(model_file)
else:
    print("Model was already trained")

history=np.load(history_file, allow_pickle='TRUE').item()
classifier = keras.models.load_model(model_file)
```

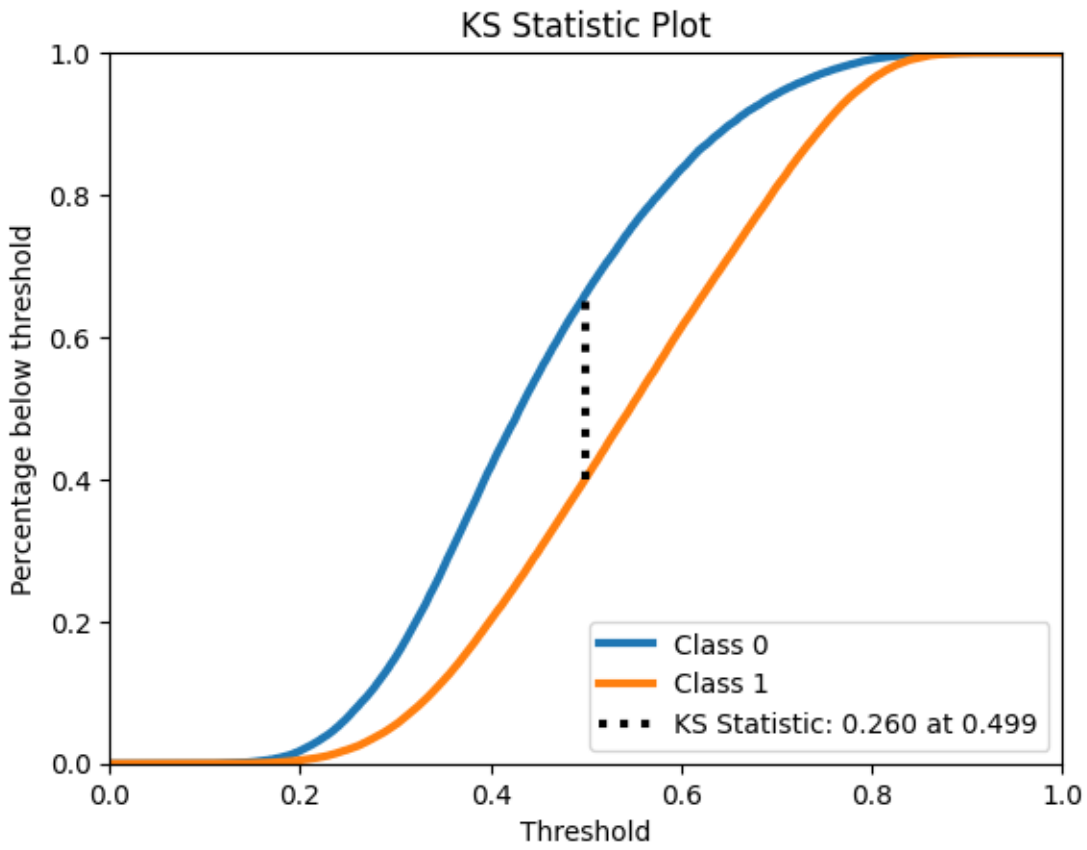
```
Model was already trained
```

[ ]:
```
# Fazer predições no conjunto de teste
y_pred_scores = classifier.predict(x_test)
y_pred_class = (y_pred_scores > 0.5).astype("int32")
y_pred_scores_0 = 1 - y_pred_scores
y_pred_scores = np.concatenate([y_pred_scores_0, y_pred_scores], axis=1)

## Matriz de confusão
print('Matriz de confusão no conjunto de teste:')
metrics.plot_confusion_matrix(y_test, y_pred_class)

## Resumo dos resultados
losses = metrics.extract_final_losses(history)
print()
print("{metric:<18}{value:.4f}".format(metric="Train Loss:",␣
 ↪value=losses['train_loss']))
print("{metric:<18}{value:.4f}".format(metric="Validation Loss:",␣
 ↪value=losses['val_loss']))
print('\nPerformance no conjunto de teste:')
accuracy, recall, precision, f1, auroc, aupr = metrics.
 ↪compute_performance_metrics(y_test, y_pred_class, y_pred_scores)
metrics.print_metrics_summary(accuracy, recall, precision, f1, auroc, aupr)
```

```
3041/3041 [==============================] - 3s 1ms/step
Matriz de confusão no conjunto de teste:

Train Loss:       0.2258
Validation Loss:  0.2255
```

Performance no conjunto de teste:






```
Accuracy:           0.6199
Recall:             0.5982
Precision:          0.7705
F1:                 0.6735
AUROC:              0.6774
AUPR:               0.7885
```

5.1.4 Experimento4

[ ]:
```
# Número de features do nosso data set.
input_dim = x_train.shape[1]

# Aqui criamos o esboço da rede.
classifier = Sequential()

classifier.add(Dense(512, activation='tanh', input_dim=input_dim))
classifier.add(Dense(256, activation='tanh', input_dim=input_dim))
classifier.add(Dense(1, activation='sigmoid'))
```

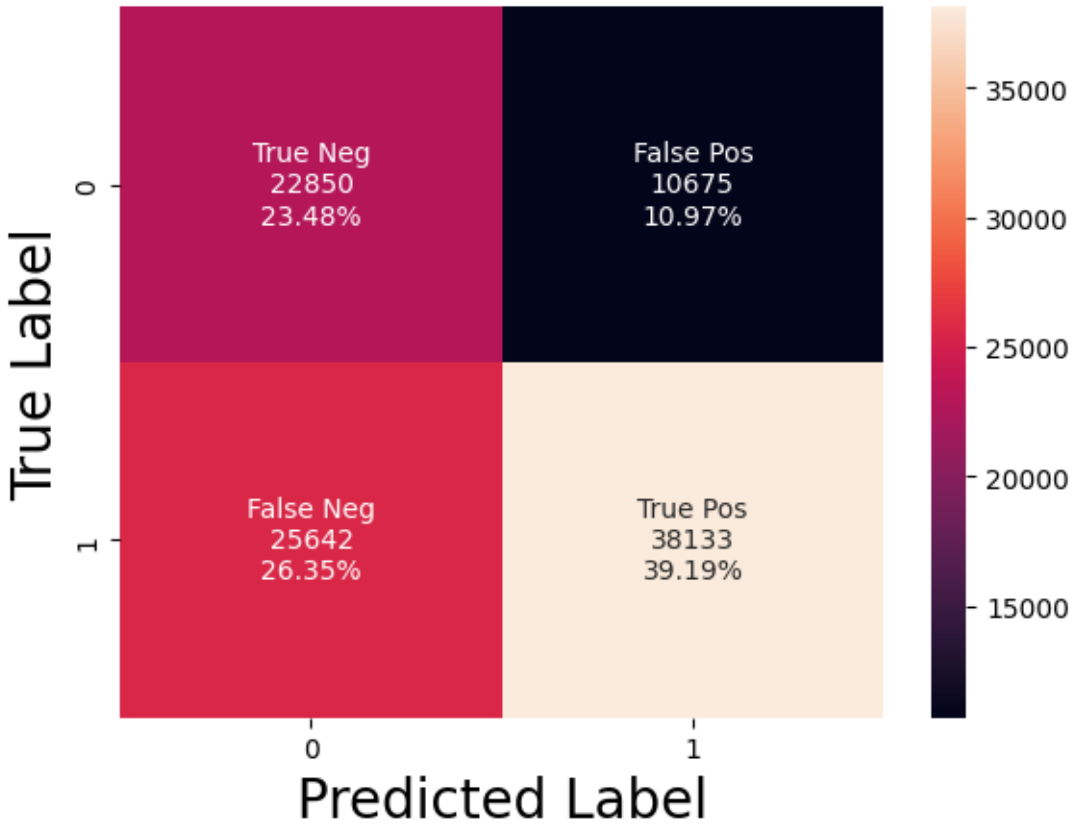
```
optimizer=keras.optimizers.SGD( learning_rate=0.01)
classifier.compile(optimizer=optimizer, loss='mean_squared_error')

history_file = HISTORY_PATH + "4.npy"
model_file = MODEL_PATH + "4"

if not exists(history_file) or  not exists(model_file):
    history = classifier.fit(x_train, y_train, batch_size=32, epochs=1_000,␣
 ↪callbacks=[EarlyStopping(patience=20,verbose=1,restore_best_weights=True)],␣
 ↪validation_data=(x_val, y_val))
    np.save(history_file,history.history)
    classifier.save(model_file)
else:
    print("Model was already trained")

history=np.load(history_file, allow_pickle='TRUE').item()
classifier = keras.models.load_model(model_file)
```

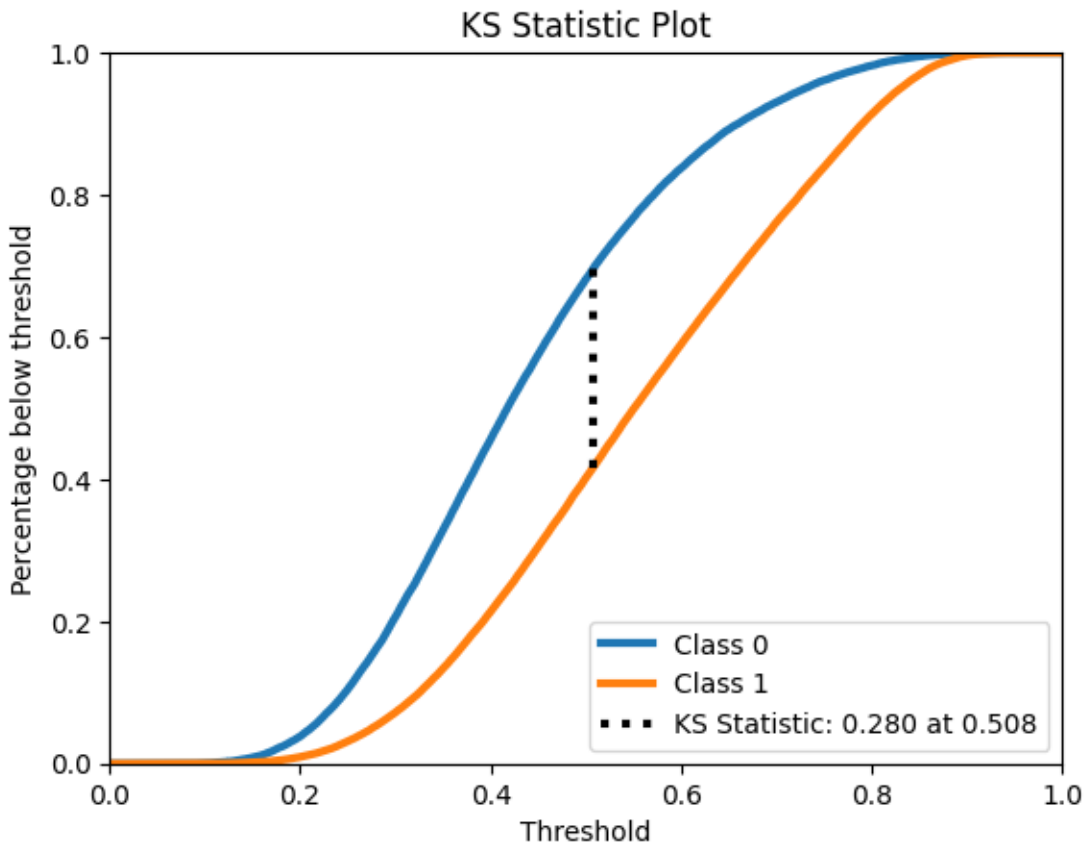
```
Model was already trained
```

[ ]:
```
# Fazer predições no conjunto de teste
y_pred_scores = classifier.predict(x_test)
y_pred_class = (y_pred_scores > 0.5).astype("int32")
y_pred_scores_0 = 1 - y_pred_scores
y_pred_scores = np.concatenate([y_pred_scores_0, y_pred_scores], axis=1)

## Matriz de confusão
print('Matriz de confusão no conjunto de teste:')
metrics.plot_confusion_matrix(y_test, y_pred_class)

## Resumo dos resultados
losses = metrics.extract_final_losses(history)
print()
print("{metric:<18}{value:.4f}".format(metric="Train Loss:",␣
 ↪value=losses['train_loss']))
print("{metric:<18}{value:.4f}".format(metric="Validation Loss:",␣
 ↪value=losses['val_loss']))
print('\nPerformance no conjunto de teste:')
accuracy, recall, precision, f1, auroc, aupr = metrics.
 ↪compute_performance_metrics(y_test, y_pred_class, y_pred_scores)
metrics.print_metrics_summary(accuracy, recall, precision, f1, auroc, aupr)
```

```
3041/3041 [==============================] - 3s 1ms/step
Matriz de confusão no conjunto de teste:

Train Loss:       0.2174
Validation Loss:  0.2212
```

Performance no conjunto de teste:






```
Accuracy:           0.6268
Recall:             0.5979
Precision:          0.7813
F1:                 0.6774
AUROC:              0.6925
AUPR:               0.8028
```

5.1.5 Experimento5

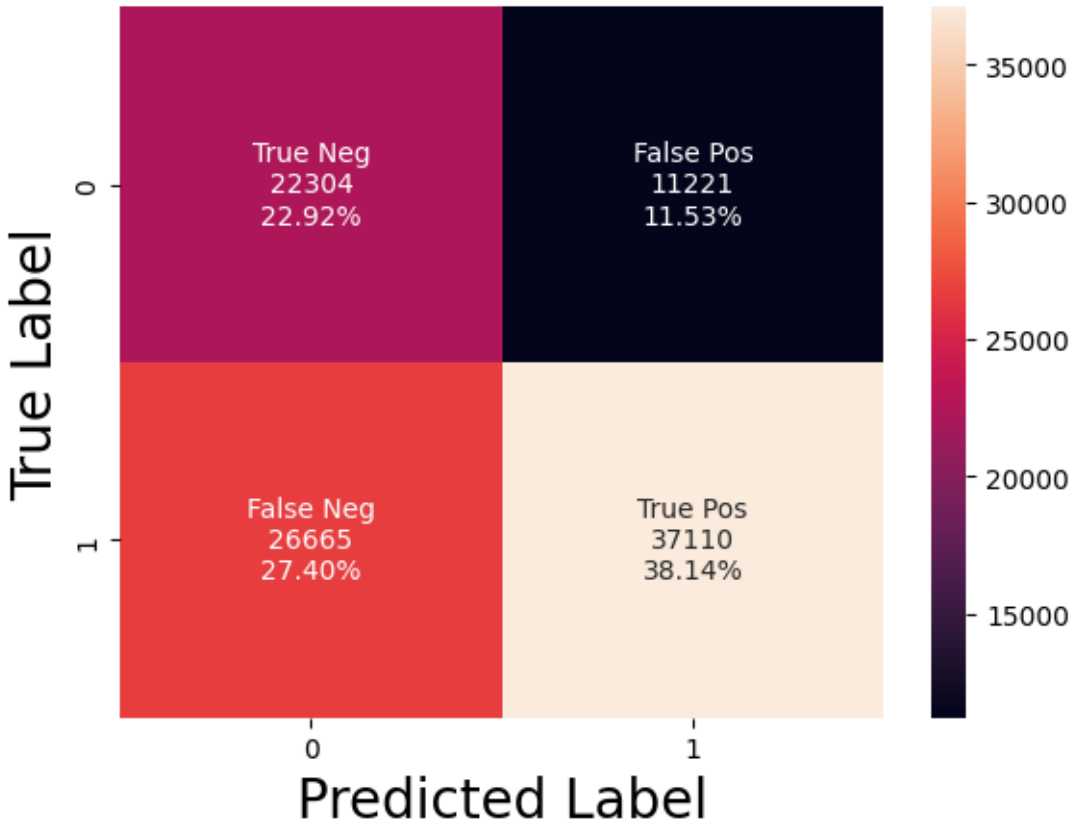
[ ]:
```
# Número de features do nosso data set.
input_dim = x_train.shape[1]

# Aqui criamos o esboço da rede.
classifier = Sequential()

classifier.add(Dense(1024, activation='tanh', input_dim=input_dim))
classifier.add(Dense(1, activation='sigmoid'))
classifier.compile(optimizer='adam', loss='mean_squared_error')
```

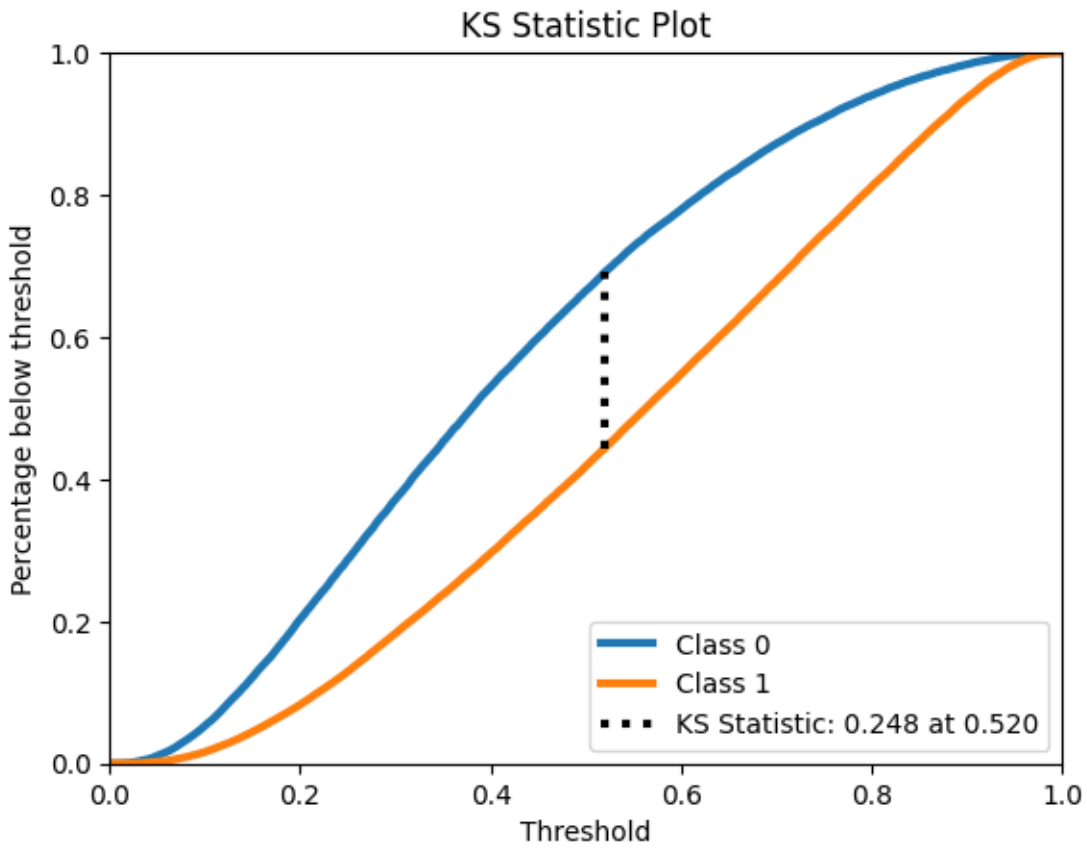
```
history_file = HISTORY_PATH + "5.npy"
model_file = MODEL_PATH + "5"

if not exists(history_file) or  not exists(model_file):
    history = classifier.fit(x_train, y_train, batch_size=32, epochs=1_000,␣
 ↪callbacks=[EarlyStopping(patience=20,verbose=1)], validation_data=(x_val,␣
 ↪y_val))
    np.save(history_file,history.history)
    classifier.save(model_file)
else:
    print("Model was already trained")

history=np.load(history_file, allow_pickle='TRUE').item()
classifier = keras.models.load_model(model_file)
```

```
Model was already trained
```

[ ]:
```
# Fazer predições no conjunto de teste
y_pred_scores = classifier.predict(x_test)
y_pred_class = (y_pred_scores > 0.5).astype("int32")
y_pred_scores_0 = 1 - y_pred_scores
y_pred_scores = np.concatenate([y_pred_scores_0, y_pred_scores], axis=1)

## Matriz de confusão
print('Matriz de confusão no conjunto de teste:')
metrics.plot_confusion_matrix(y_test, y_pred_class)

## Resumo dos resultados
losses = metrics.extract_final_losses(history)
print()
print("{metric:<18}{value:.4f}".format(metric="Train Loss:",␣
 ↪value=losses['train_loss']))
print("{metric:<18}{value:.4f}".format(metric="Validation Loss:",␣
 ↪value=losses['val_loss']))
print('\nPerformance no conjunto de teste:')
accuracy, recall, precision, f1, auroc, aupr = metrics.
 ↪compute_performance_metrics(y_test, y_pred_class, y_pred_scores)
metrics.print_metrics_summary(accuracy, recall, precision, f1, auroc, aupr)
```

```
3041/3041 [==============================] - 3s 1ms/step
Matriz de confusão no conjunto de teste:

Train Loss:       0.2259
Validation Loss:  0.2234

Performance no conjunto de teste:
```


True Neg
22304
22.92%
False Pos
11221
11.53%
False Neg
26665
27.40%
True Pos
37110
38.14%
True Label
Predicted Label
0
1
0
1
35000
30000
25000
20000
15000




```
Accuracy:           0.6106
Recall:             0.5819
Precision:          0.7678
F1:                 0.6621
AUROC:              0.6690
AUPR:               0.7847
```

5.2 MLP Ensemble

[ ]:

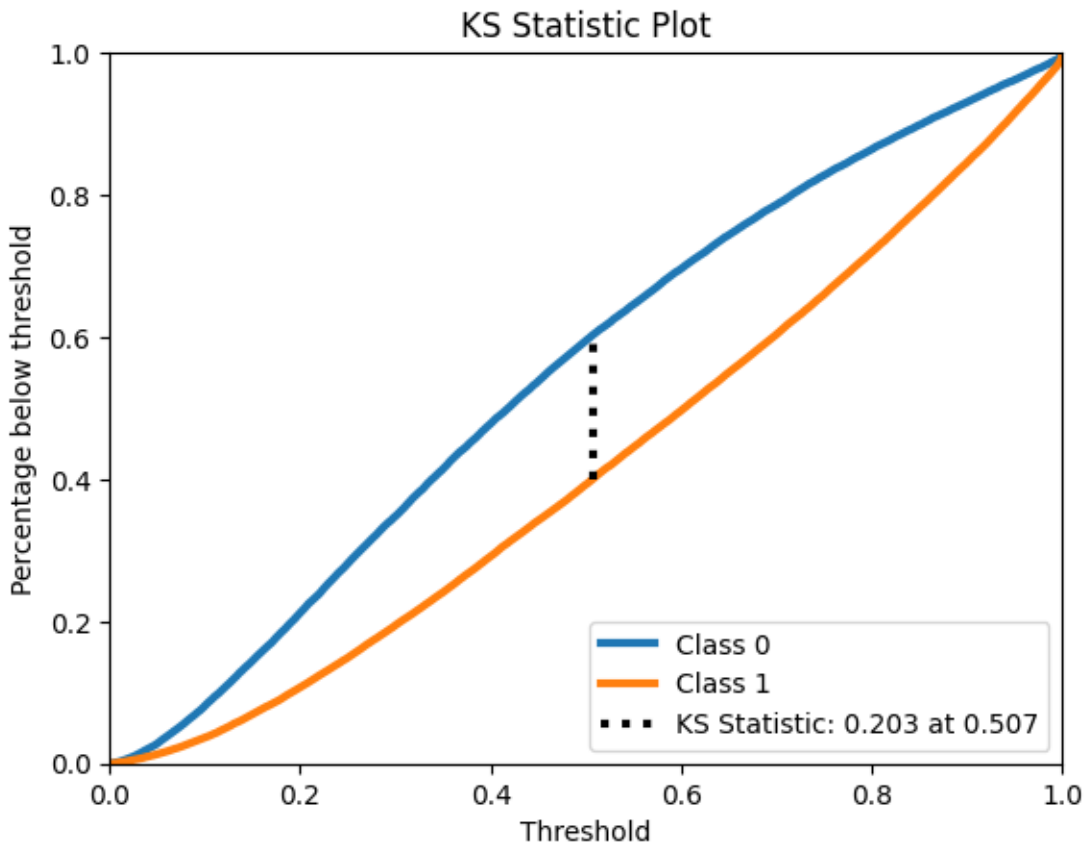
[ ]:
```
MLP_ENS_PATH = "Models/MLP_ENS"
MLP_MODEL_ENS_PATH = f"{MLP_ENS_PATH}/model"
```

5.2.1 Experimento1

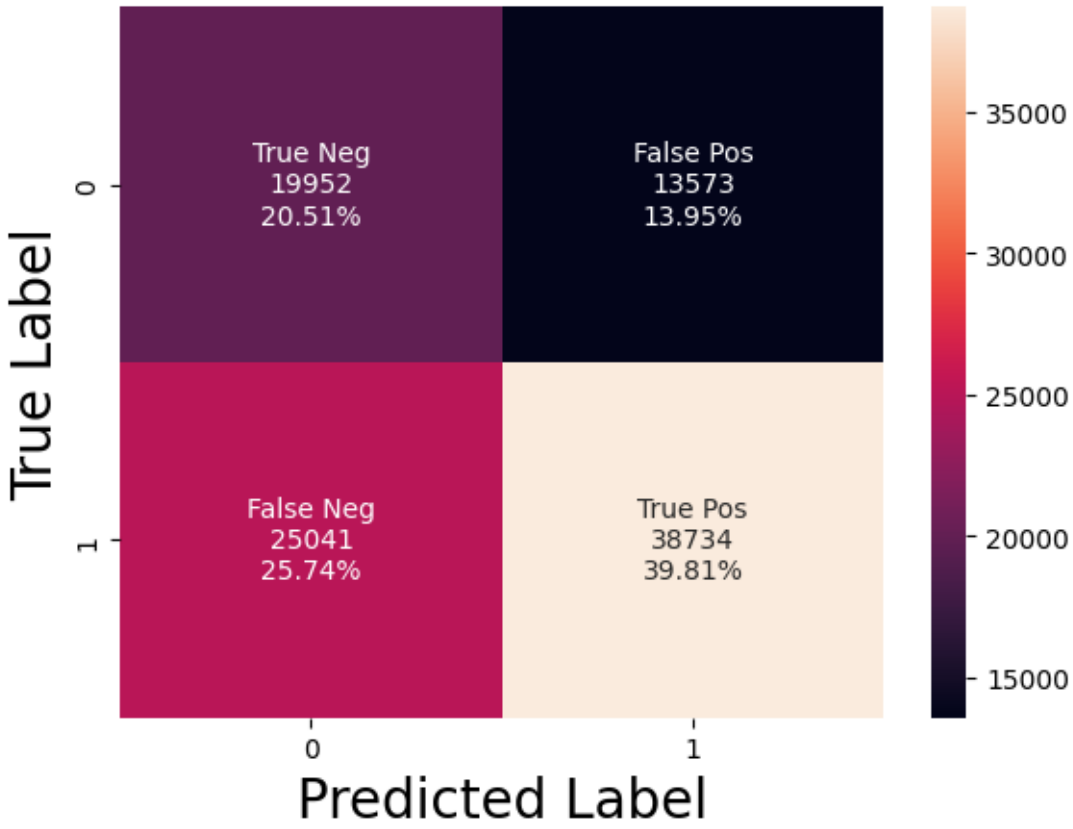
[ ]:
```
mlp = MLPClassifier(verbose=True)
mlp1 = MLPClassifier(verbose=True)
mlp2 = MLPClassifier(verbose=True)

model_file = MLP_MODEL_ENS_PATH+"1"
if not exists(model_file):
    mlp_ns = mlp.fit(x_train,y_train)
    mlp_ens = VotingClassifier([('mlp1', mlp1), ('mlp2', mlp2), ('mlp3',␣
 ↪mlp1)], voting='soft')
    mlp_ens.fit(x_train,y_train)
    with open(MLP_MODEL_ENS_PATH+"1", 'wb') as file:
        pickle.dump(mlp_ens,file)
    with open(MLP_MODEL_ENS_PATH+"ns"+"1", 'wb') as file:
        pickle.dump(mlp_ns,file)
else:
    print("Model was already trained")
    with open(MLP_MODEL_ENS_PATH+"1", 'rb') as file:
        mlp_ens = pickle.load(file)
    with open(MLP_MODEL_ENS_PATH+"ns"+"1", 'rb') as file:
        mlp_ns= pickle.load(file)
```

```
Model was already trained
```

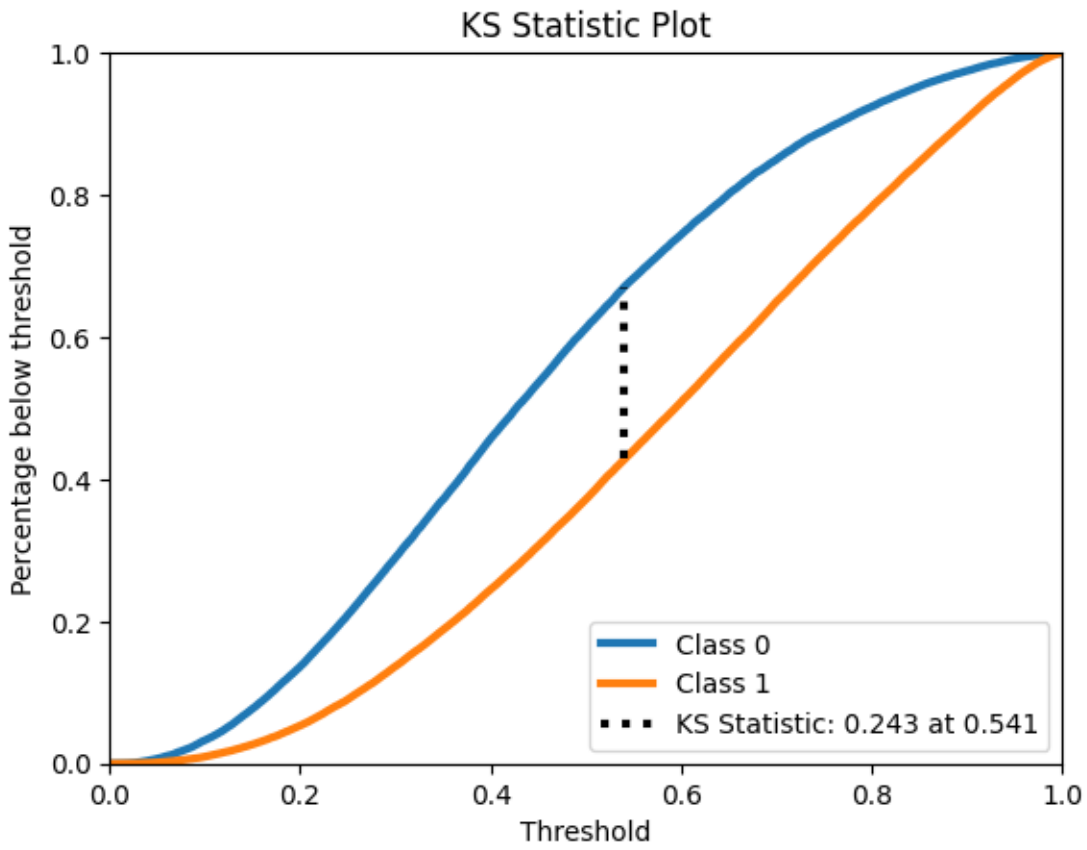
[ ]:
```
mlp_pred_class = mlp_ns.predict(x_test)
mlp_pred_scores = mlp_ns.predict_proba(x_test)
accuracy, recall, precision, f1, auroc, aupr = metrics.
 ↪compute_performance_metrics(y_test, mlp_pred_class, mlp_pred_scores)
print('Performance no conjunto de validação:')
metrics.print_metrics_summary(accuracy, recall, precision, f1, auroc, aupr)
metrics.plot_confusion_matrix(y_test, mlp_pred_class)
```



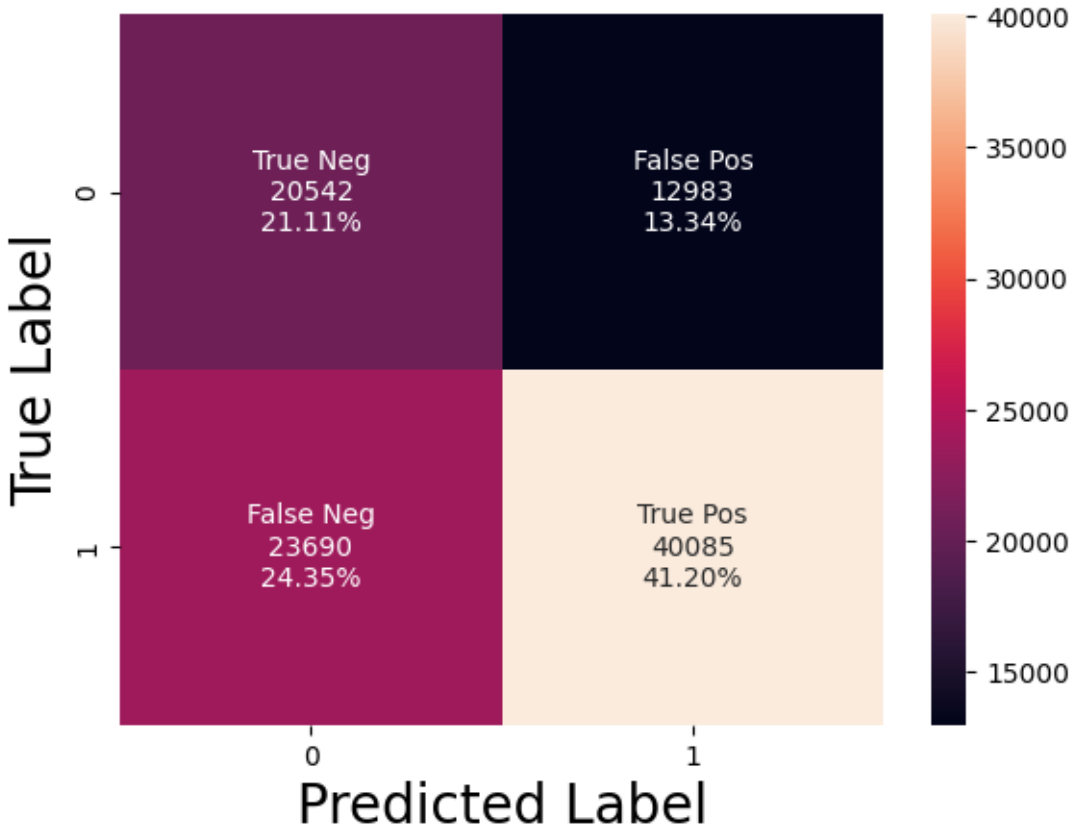

```
Performance no conjunto de validação:

Accuracy:          0.6031
Recall:            0.6074
Precision:         0.7405
F1:                0.6674
AUROC:             0.6362
AUPR:              0.7523
```



[ ]:
```
mlp_pred_class = mlp_ens.predict(x_test)
mlp_pred_scores = mlp_ens.predict_proba(x_test)
accuracy, recall, precision, f1, auroc, aupr = metrics.
 ↪compute_performance_metrics(y_test, mlp_pred_class, mlp_pred_scores)
print('Performance no conjunto de validação:')
metrics.print_metrics_summary(accuracy, recall, precision, f1, auroc, aupr)
metrics.plot_confusion_matrix(y_test, mlp_pred_class)
```




```
Performance no conjunto de validação:

Accuracy:          0.6231
Recall:            0.6285
Precision:         0.7554
F1:                0.6861
AUROC:             0.6652
AUPR:              0.7821
```

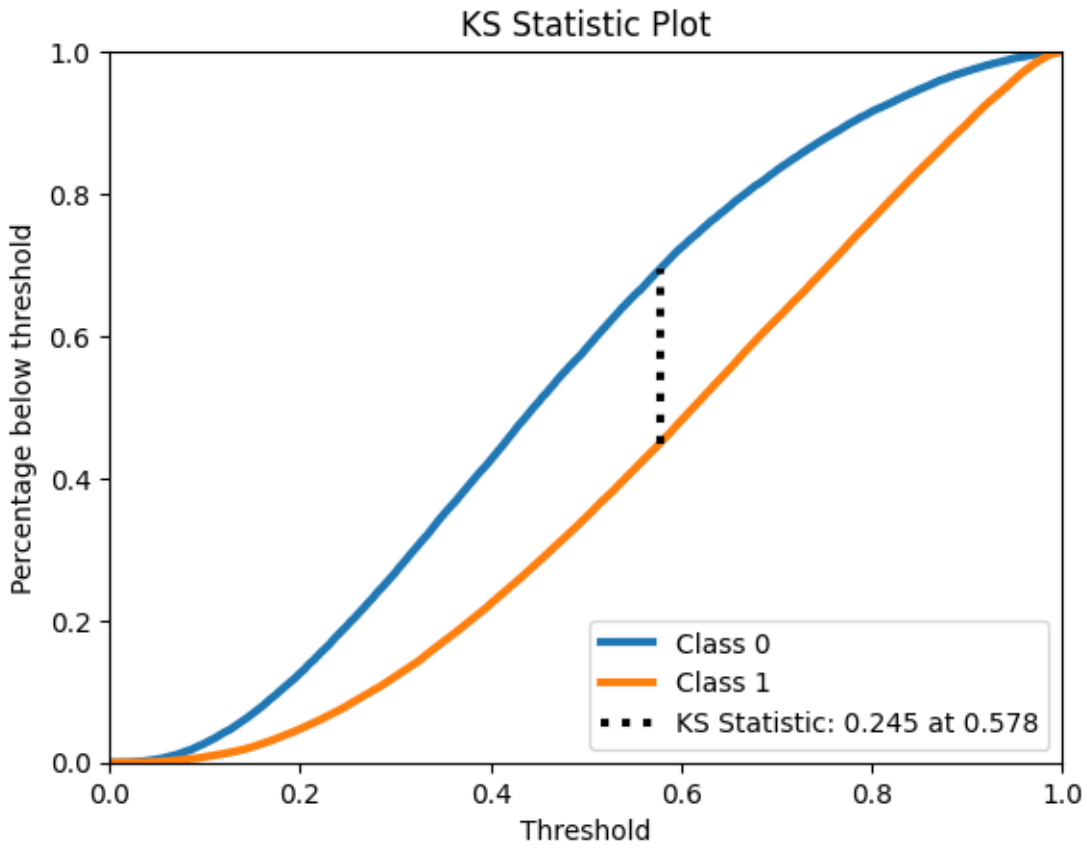


5.2.2 Experimento2

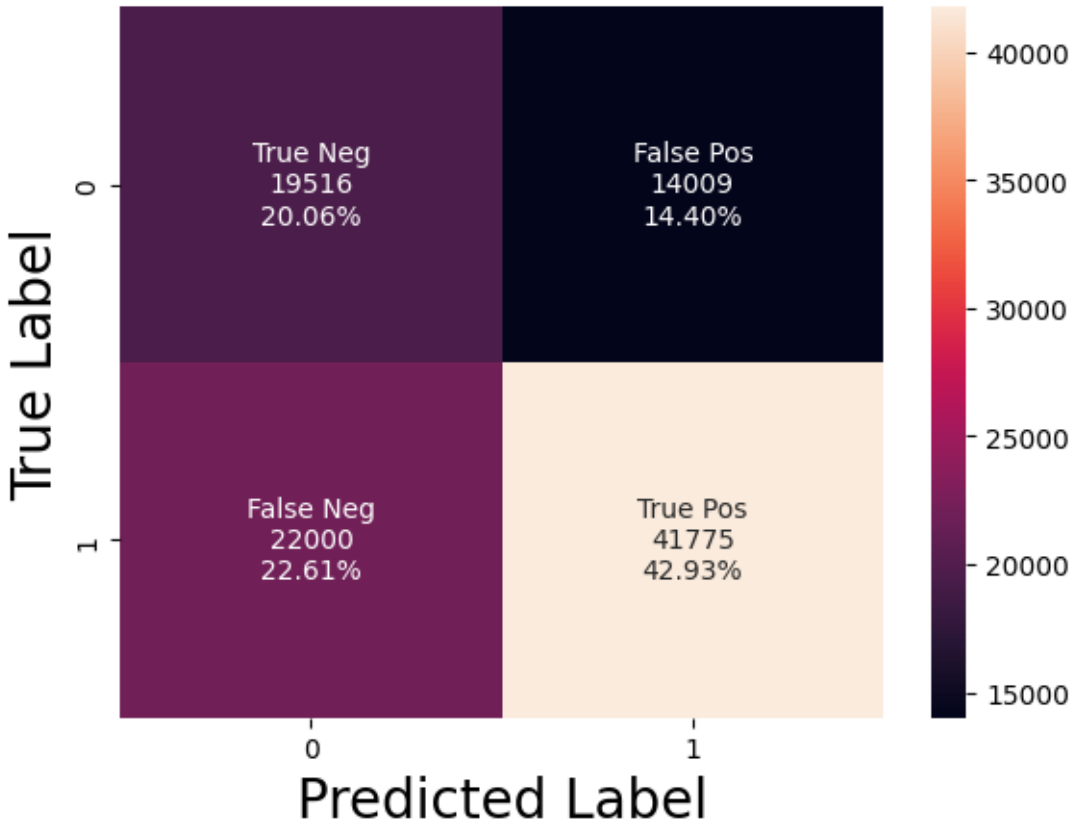
[ ]:
```
mlp1 = MLPClassifier(activation="relu",verbose=True)
mlp2 = MLPClassifier(activation="logistic", verbose=True)
mlp3 = MLPClassifier(activation="tanh", verbose=True)

model_file = MLP_MODEL_ENS_PATH+"2"
if not exists(model_file):
    mlp_ens = VotingClassifier([('mlp1', mlp1), ('mlp2', mlp2), ('mlp3',␣
 ↪mlp3)], voting='soft')
    mlp_ens.fit(x_train,y_train)
    with open(model_file, 'wb') as file:
        pickle.dump(mlp_ens,file)
else:
    print("Model was already trained")
    with open(model_file, 'rb') as file:
        mlp_ens = pickle.load(file)
```

```
Model was already trained
```

[ ]:
```
mlp_pred_class = mlp_ens.predict(x_test)
mlp_pred_scores = mlp_ens.predict_proba(x_test)
accuracy, recall, precision, f1, auroc, aupr = metrics.
  ↪compute_performance_metrics(y_test, mlp_pred_class, mlp_pred_scores)
print('Performance no conjunto de validação:')
metrics.print_metrics_summary(accuracy, recall, precision, f1, auroc, aupr)
metrics.plot_confusion_matrix(y_test, mlp_pred_class)
```




```
Performance no conjunto de validação:

Accuracy:         0.6299
Recall:           0.6550
Precision:        0.7489
F1:               0.6988
AUROC:            0.6665
AUPR:             0.7825
```

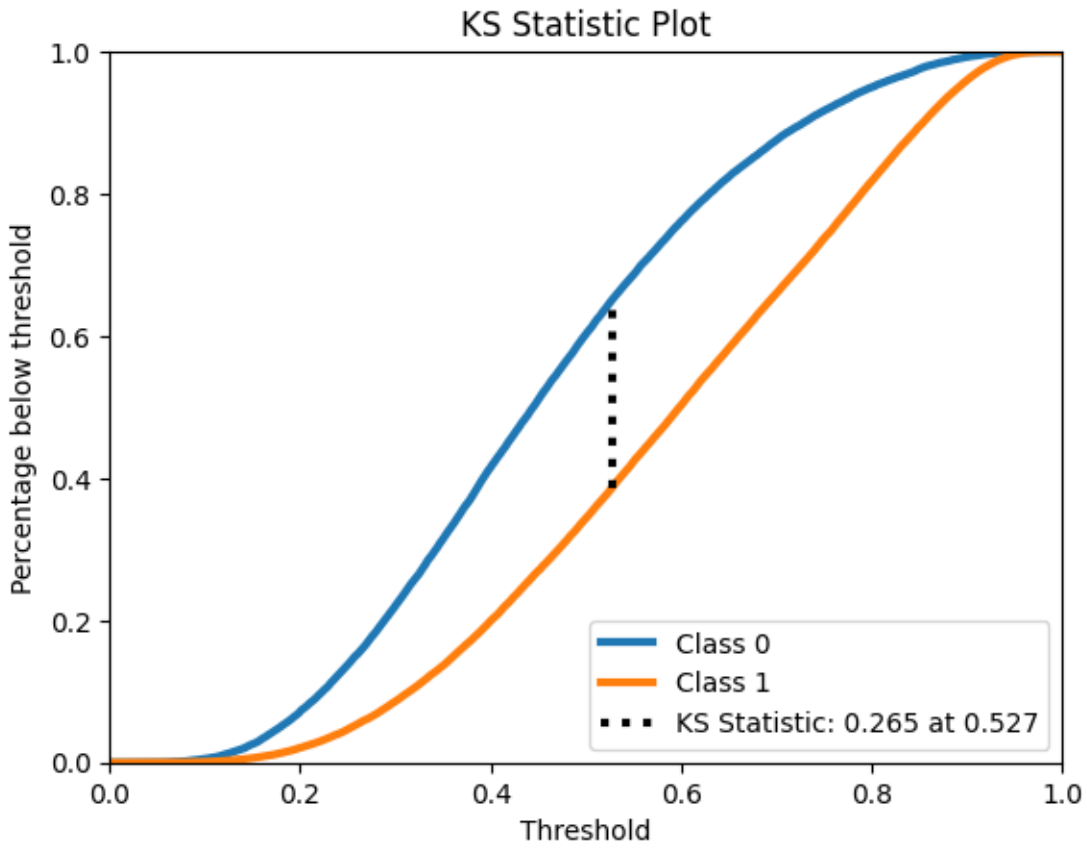


5.2.3 Experimento3

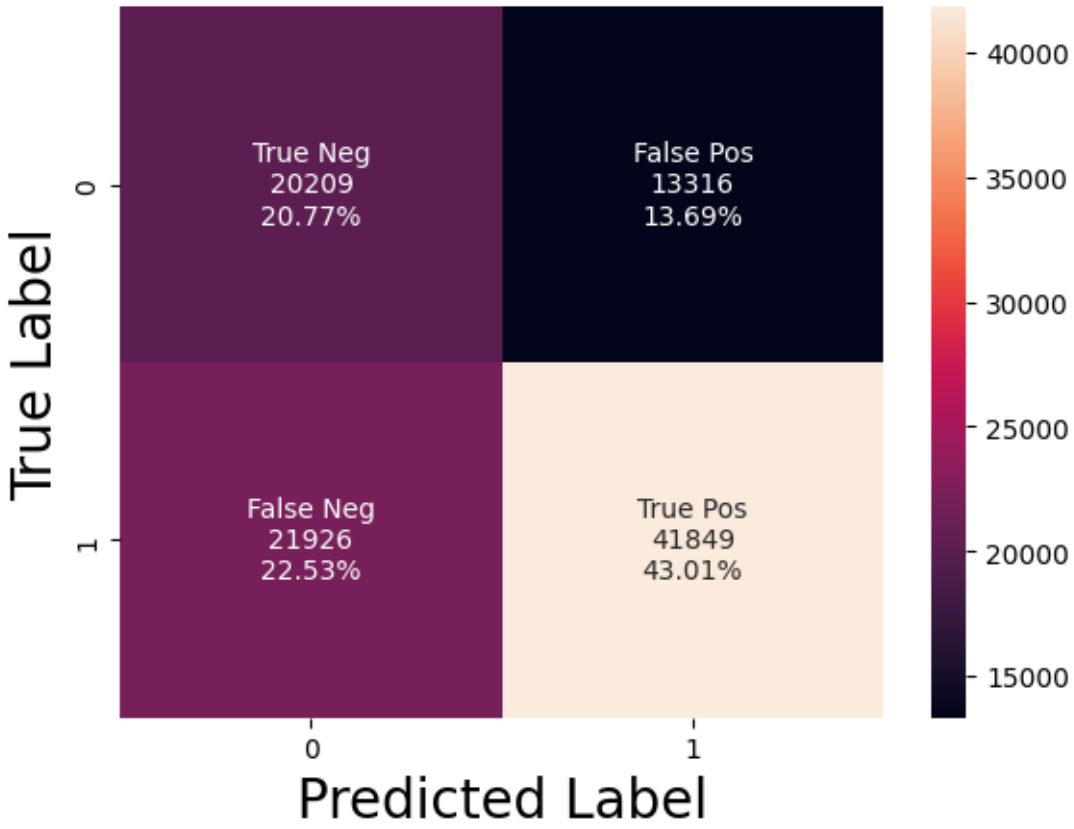
[ ]:
```
mlp1 = MLPClassifier(solver="lbfgs",verbose=True)
mlp2 = MLPClassifier(solver="sgd", verbose=True)
mlp3 = MLPClassifier(solver="adam", verbose=True)

model_file = MLP_MODEL_ENS_PATH+"3"
if not exists(model_file):
    mlp_ens = VotingClassifier([('mlp1', mlp1), ('mlp2', mlp2), ('mlp3',␣
 ↪mlp3)], voting='soft')
    mlp_ens.fit(x_train,y_train)
    with open(model_file, 'wb') as file:
        pickle.dump(mlp_ens,file)
else:
    print("Model was already trained")
    with open(model_file, 'rb') as file:
        mlp_ens = pickle.load(file)
```

```
Model was already trained
```

[ ]:
```
mlp_pred_class = mlp_ens.predict(x_test)
mlp_pred_scores = mlp_ens.predict_proba(x_test)
accuracy, recall, precision, f1, auroc, aupr = metrics.
  ↪compute_performance_metrics(y_test, mlp_pred_class, mlp_pred_scores)
print('Performance no conjunto de validação:')
metrics.print_metrics_summary(accuracy, recall, precision, f1, auroc, aupr)
metrics.plot_confusion_matrix(y_test, mlp_pred_class)
```




```
Performance no conjunto de validação:

Accuracy:         0.6378
Recall:           0.6562
Precision:        0.7586
F1:               0.7037
AUROC:            0.6820
AUPR:             0.7963
```



5.3 Gradient Boosting

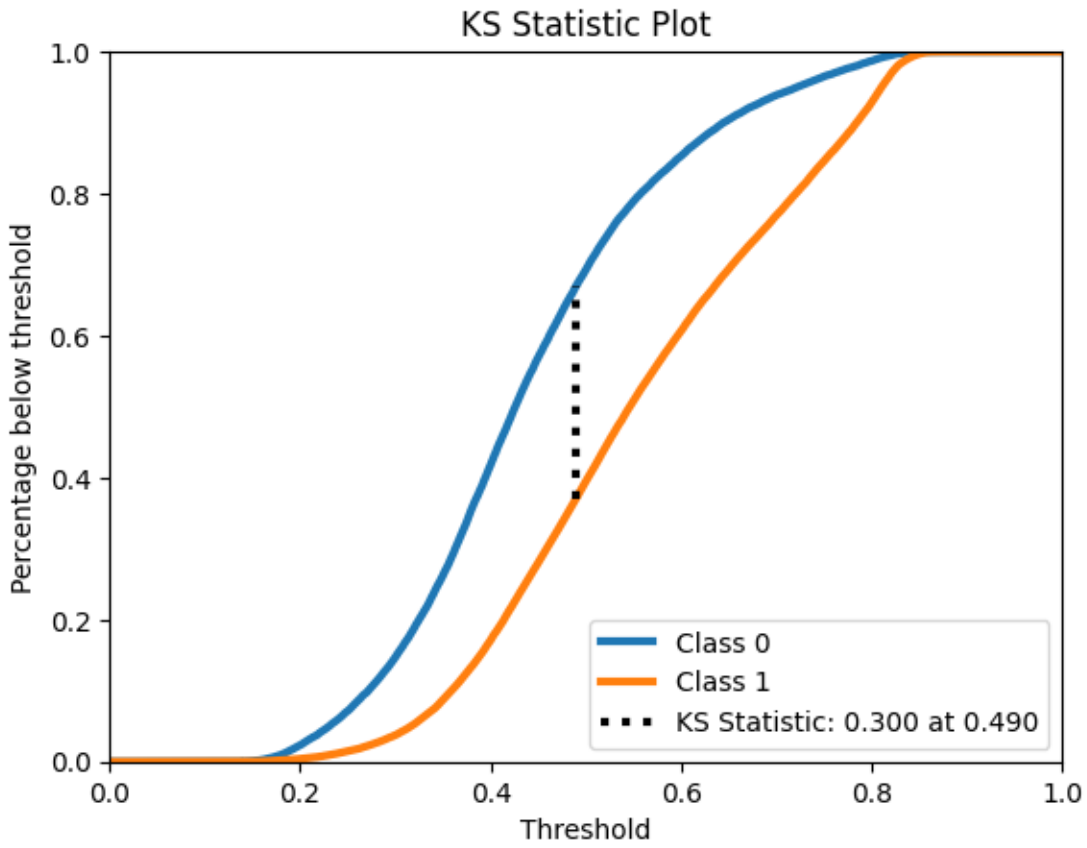
[ ]:
```
GB_PATH = "Models/GB"
GB_MODEL_PATH = f"{GB_PATH}/model"
```

5.3.1 Experimento1

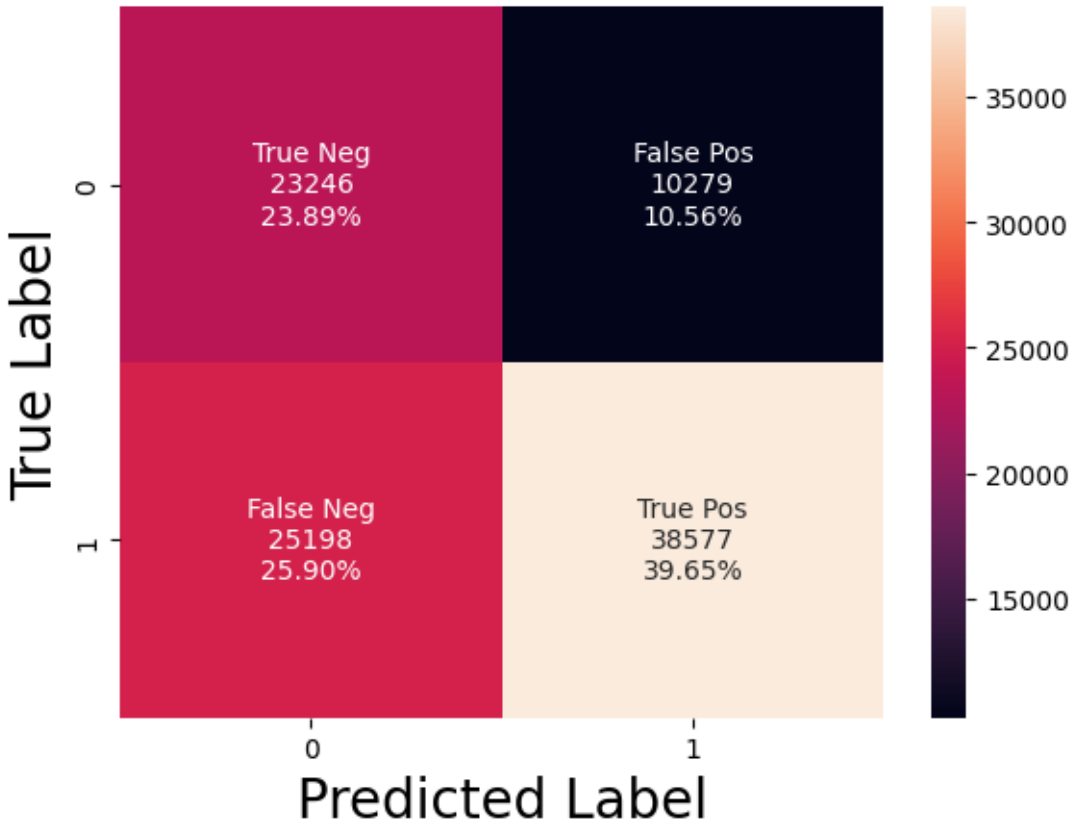
[ ]:
```
gb_clf = GradientBoostingClassifier()

model_file = GB_MODEL_PATH+"1"
if not exists(model_file):
    gb_clf.fit(x_train, y_train)
    with open(model_file, 'wb') as file:
        pickle.dump(gb_clf,file)
else:
    print("Model was already trained")
    with open(model_file, 'rb') as file:
        gb_clf = pickle.load(file)

gb_pred_class = gb_clf.predict(x_test)
```

```
gb_pred_scores = gb_clf.predict_proba(x_test)
accuracy, recall, precision, f1, auroc, aupr = metrics.
  ↪compute_performance_metrics(y_test, gb_pred_class, gb_pred_scores)
metrics.print_metrics_summary(accuracy, recall, precision, f1, auroc, aupr)
metrics.plot_confusion_matrix(y_test, gb_pred_class)
```

```
Model was already trained
```



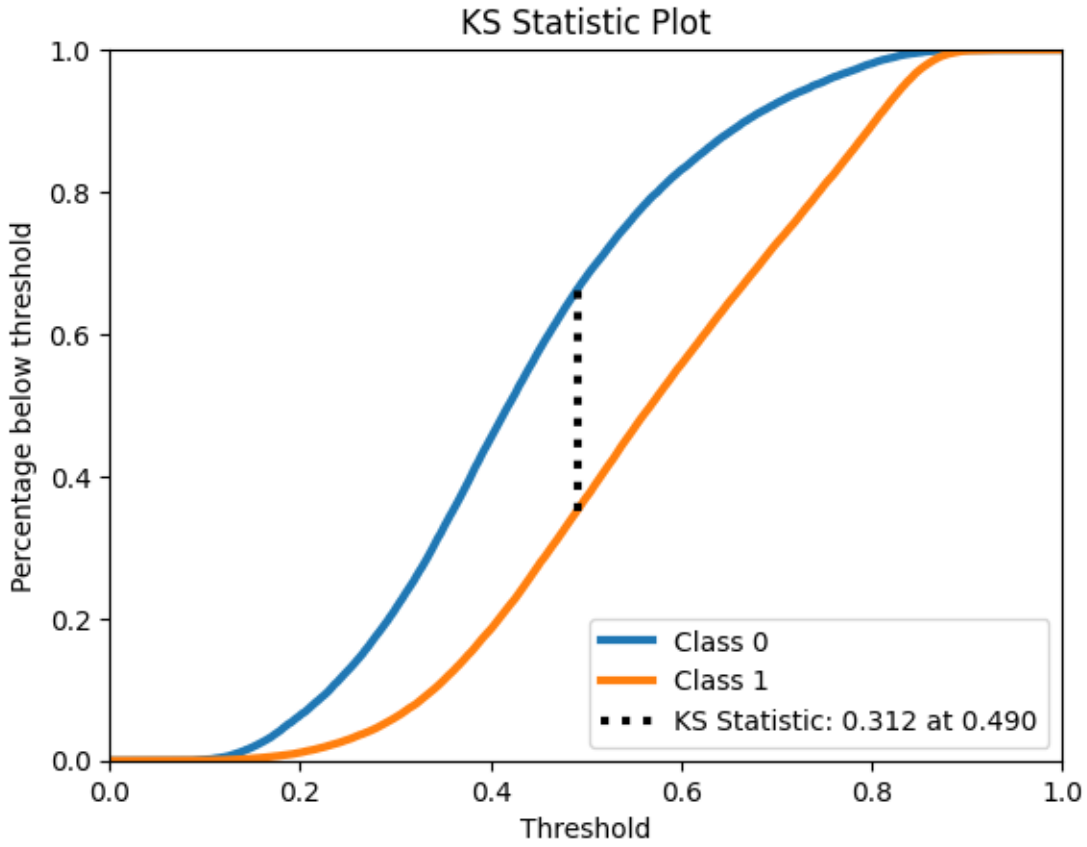

```
Accuracy:          0.6354
Recall:            0.6049
Precision:         0.7896
F1:                0.6850
AUROC:             0.7054
AUPR:              0.8101
```



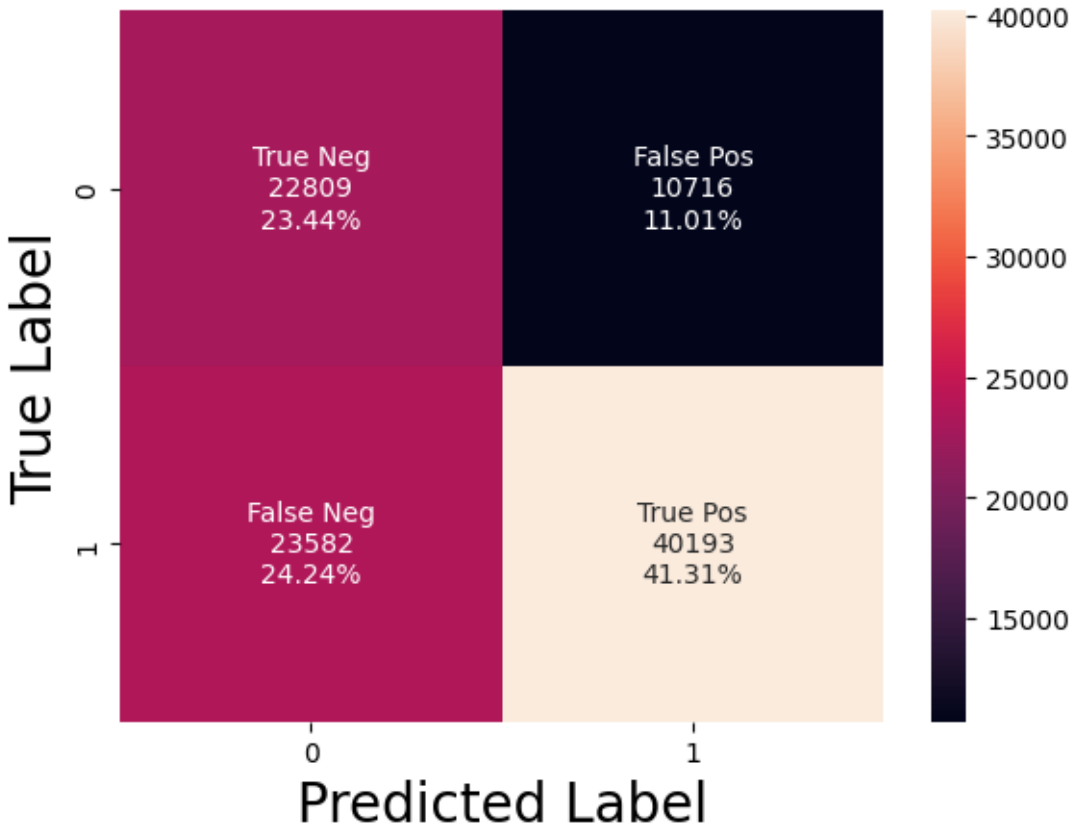
5.3.2 Experimento2

[ ]:
```
gb_clf = GradientBoostingClassifier(n_estimators=500)

model_file = GB_MODEL_PATH+"2"
if not exists(model_file):
    gb_clf.fit(x_train, y_train)
    with open(model_file, 'wb') as file:
        pickle.dump(gb_clf,file)
else:
    print("Model was already trained")
    with open(model_file, 'rb') as file:
        gb_clf = pickle.load(file)

gb_pred_class = gb_clf.predict(x_test)
gb_pred_scores = gb_clf.predict_proba(x_test)
accuracy, recall, precision, f1, auroc, aupr = metrics.
 ↪compute_performance_metrics(y_test, gb_pred_class, gb_pred_scores)
metrics.print_metrics_summary(accuracy, recall, precision, f1, auroc, aupr)
metrics.plot_confusion_matrix(y_test, gb_pred_class)
```

```
Model was already trained
```



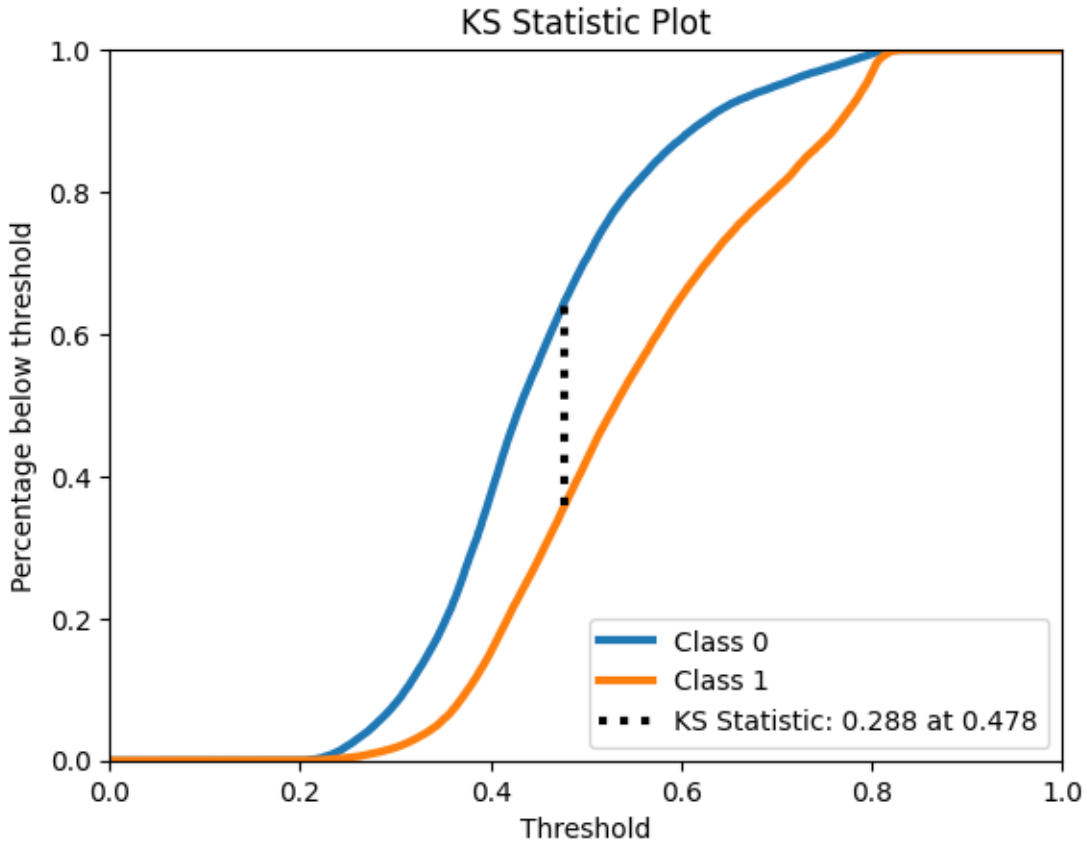
Accuracy:	0.6475
Recall:	0.6302
Precision:	0.7895
F1:	0.7009
AUROC:	0.7130
AUPR:	0.8162



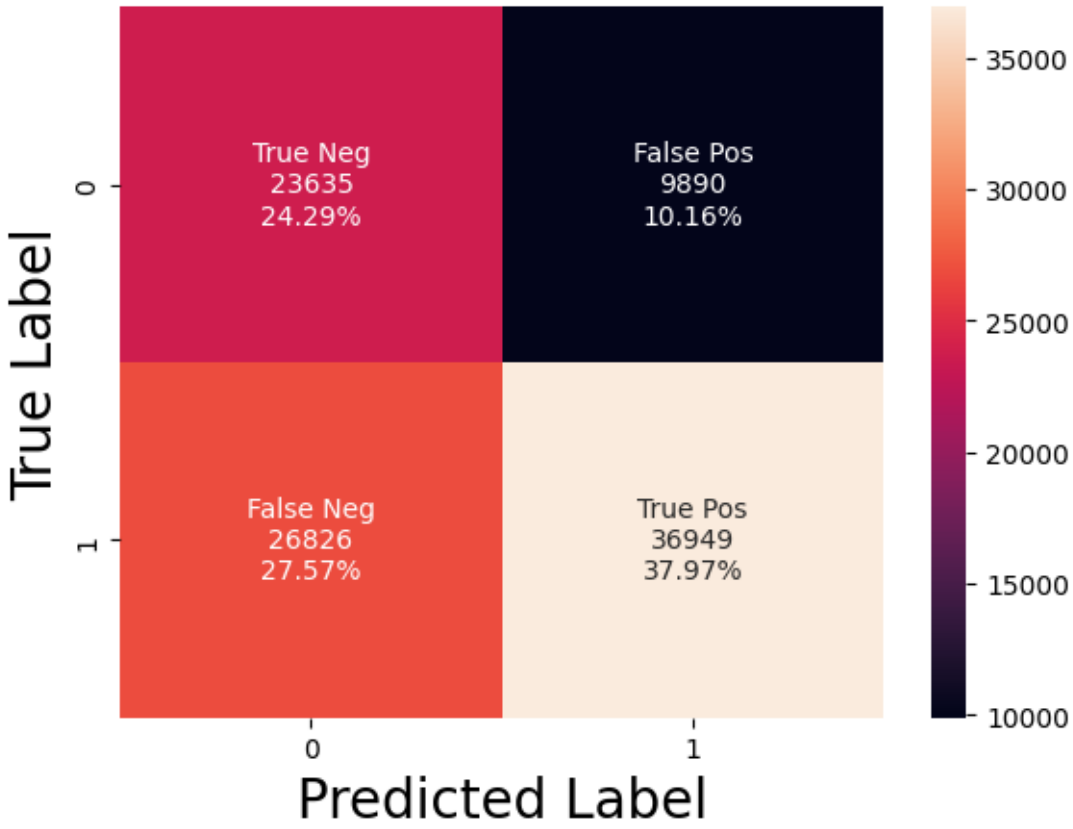
5.3.3 Experimento3

[ ]:
```
gb_clf = GradientBoostingClassifier(n_estimators=50)

model_file = GB_MODEL_PATH+"3"
if not exists(model_file):
    gb_clf.fit(x_train, y_train)
    with open(model_file, 'wb') as file:
        pickle.dump(gb_clf,file)
else:
    print("Model was already trained")
    with open(model_file, 'rb') as file:
        gb_clf = pickle.load(file)

gb_pred_class = gb_clf.predict(x_test)
gb_pred_scores = gb_clf.predict_proba(x_test)
accuracy, recall, precision, f1, auroc, aupr = metrics.
 ↪compute_performance_metrics(y_test, gb_pred_class, gb_pred_scores)
metrics.print_metrics_summary(accuracy, recall, precision, f1, auroc, aupr)
metrics.plot_confusion_matrix(y_test, gb_pred_class)
```

```
Model was already trained
```



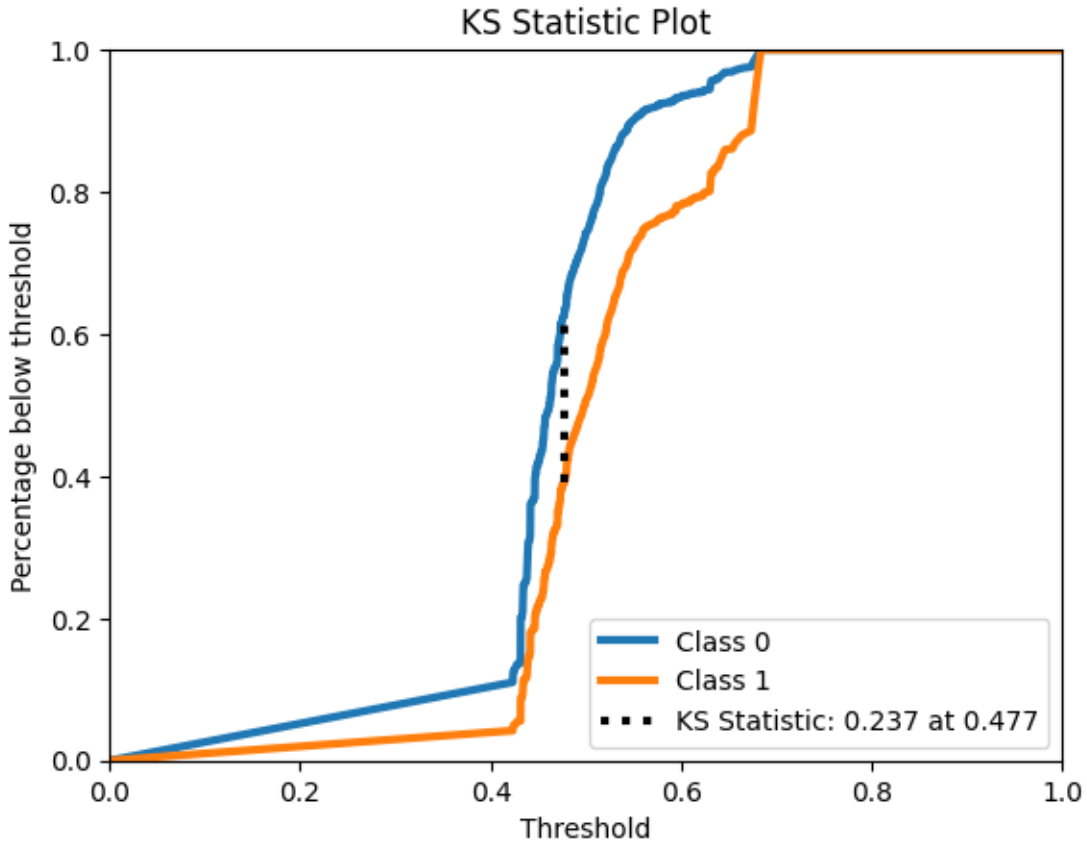

```
Accuracy:          0.6227
Recall:            0.5794
Precision:         0.7889
F1:                0.6681
AUROC:             0.6982
AUPR:              0.8054
```



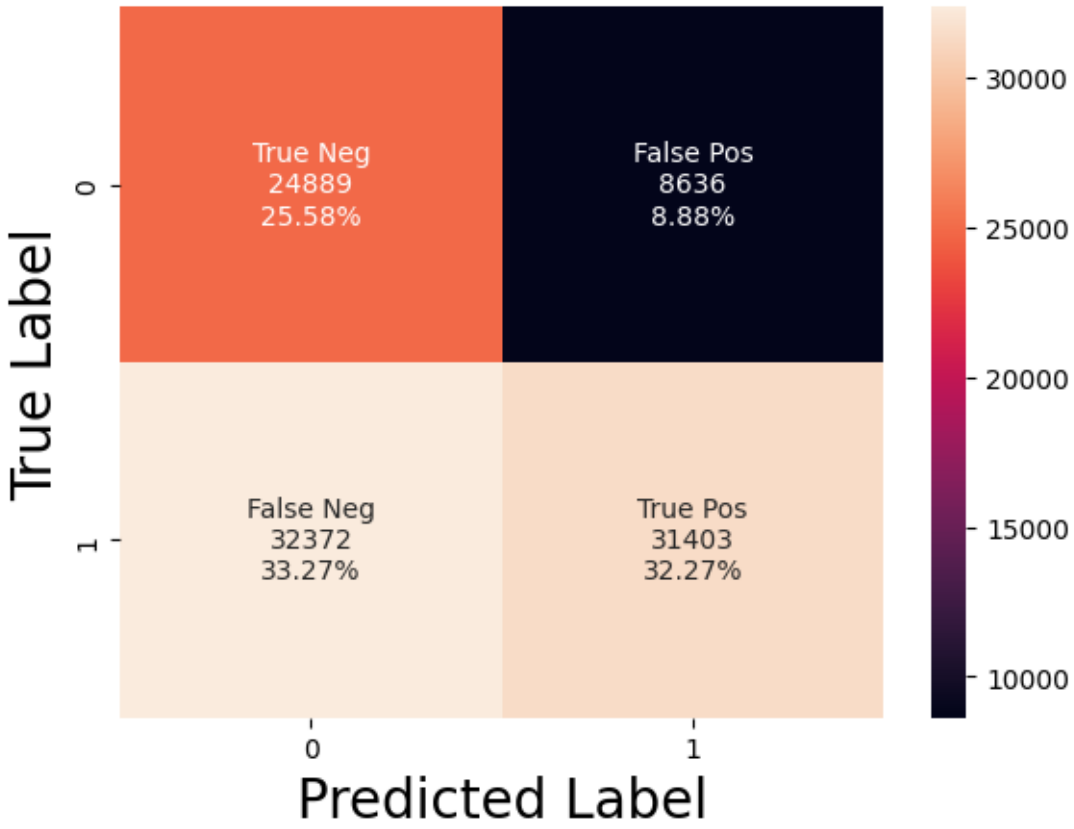
5.3.4 Experimento4

[ ]:
```
gb_clf = GradientBoostingClassifier(n_estimators=10)

model_file = GB_MODEL_PATH+"4"
if not exists(model_file):
    gb_clf.fit(x_train, y_train)
    with open(model_file, 'wb') as file:
        pickle.dump(gb_clf,file)
else:
    print("Model was already trained")
    with open(model_file, 'rb') as file:
        gb_clf = pickle.load(file)

gb_pred_class = gb_clf.predict(x_test)
gb_pred_scores = gb_clf.predict_proba(x_test)
accuracy, recall, precision, f1, auroc, aupr = metrics.
 ↪compute_performance_metrics(y_test, gb_pred_class, gb_pred_scores)
metrics.print_metrics_summary(accuracy, recall, precision, f1, auroc, aupr)
metrics.plot_confusion_matrix(y_test, gb_pred_class)
```

```
Model was already trained
```



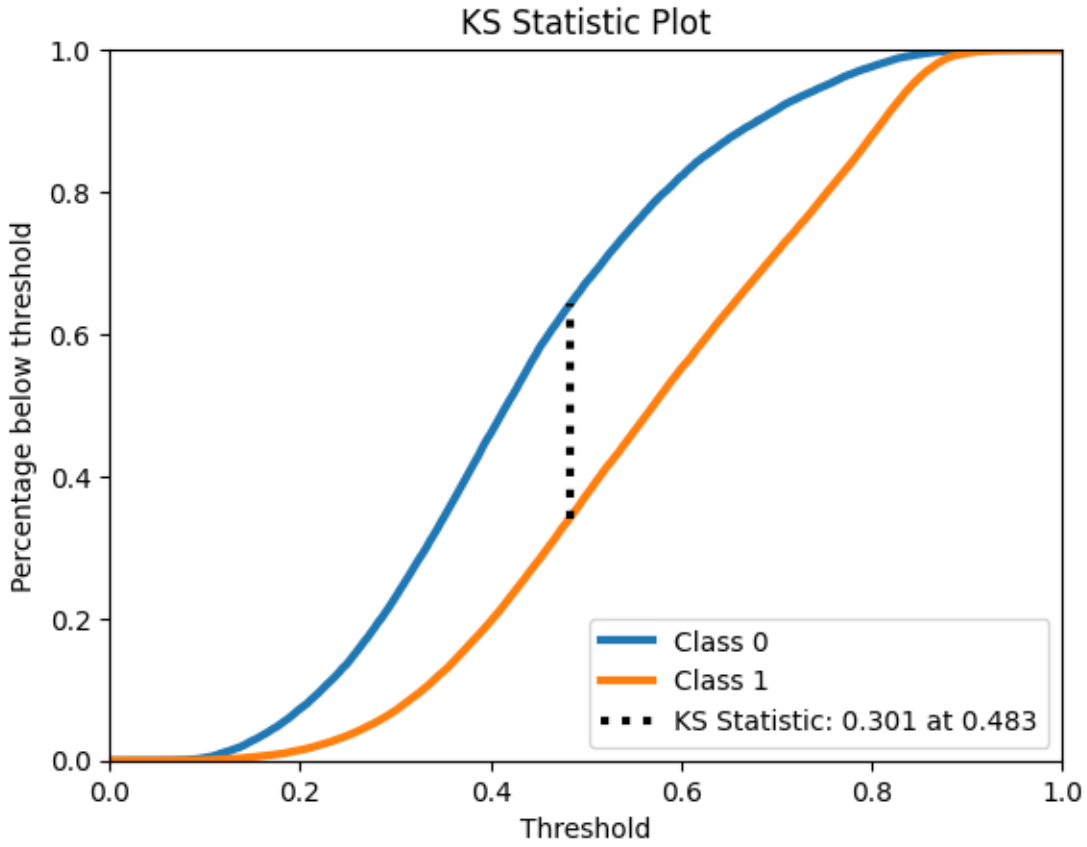

```
Accuracy:           0.5785
Recall:             0.4924
Precision:          0.7843
F1:                 0.6050
AUROC:              0.6666
AUPR:               0.7870
```



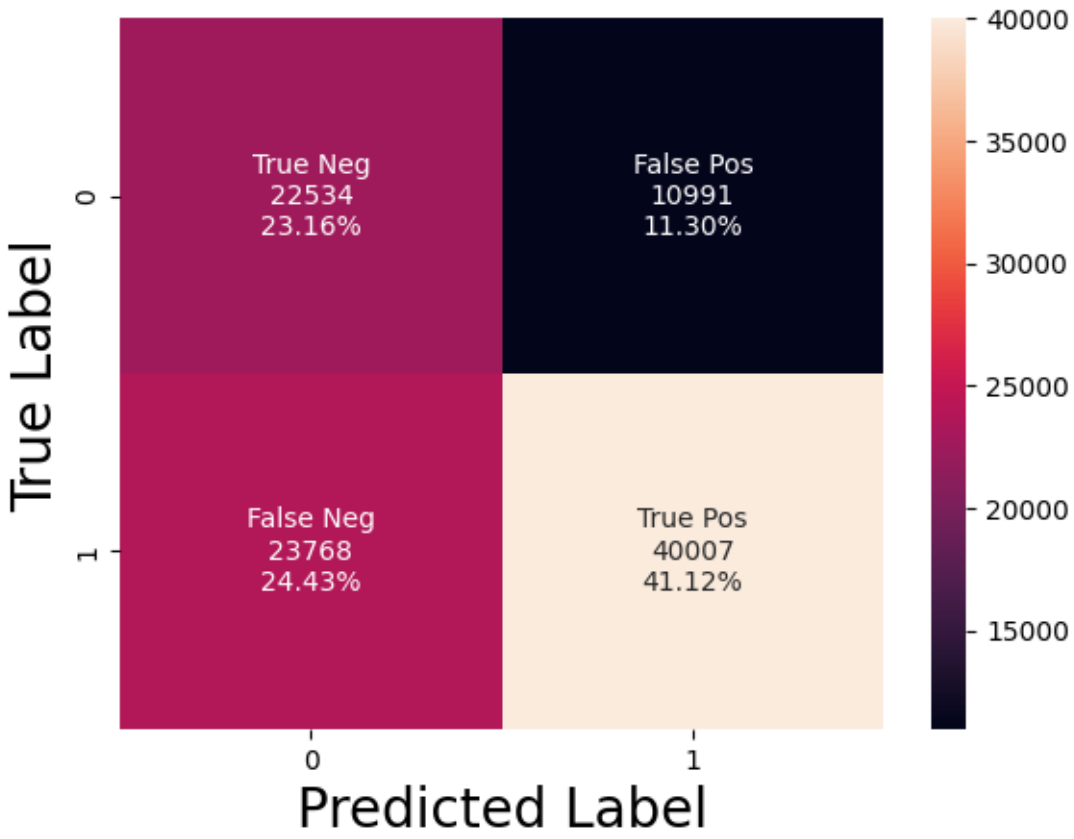
5.3.5 Experimento5

[ ]:
```
gb_clf = GradientBoostingClassifier(learning_rate=0.5)

model_file = GB_MODEL_PATH+"5"
if not exists(model_file):
    gb_clf.fit(x_train, y_train)
    with open(model_file, 'wb') as file:
        pickle.dump(gb_clf,file)
else:
    print("Model was already trained")
    with open(model_file, 'rb') as file:
        gb_clf = pickle.load(file)

gb_pred_class = gb_clf.predict(x_test)
gb_pred_scores = gb_clf.predict_proba(x_test)
accuracy, recall, precision, f1, auroc, aupr = metrics.
 ↪compute_performance_metrics(y_test, gb_pred_class, gb_pred_scores)
metrics.print_metrics_summary(accuracy, recall, precision, f1, auroc, aupr)
metrics.plot_confusion_matrix(y_test, gb_pred_class)
```

```
Model was already trained
```



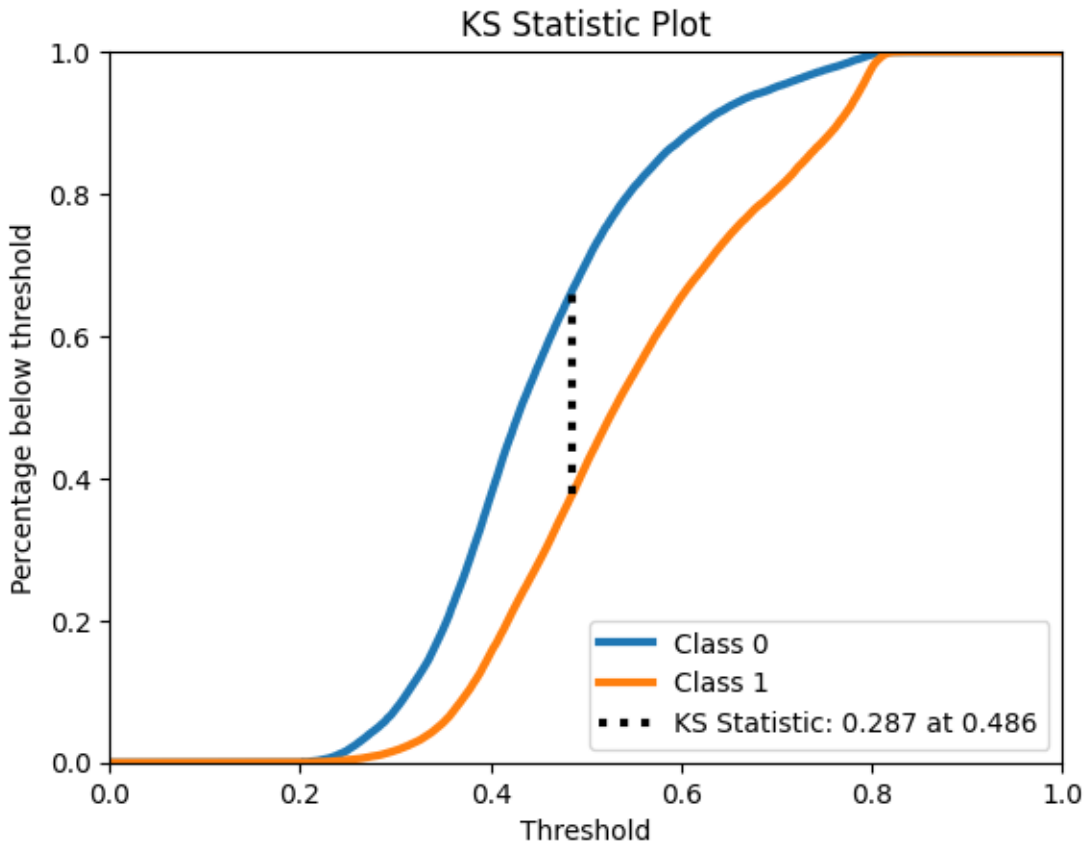

```
Accuracy:          0.6428
Recall:            0.6273
Precision:         0.7845
F1:                0.6972
AUROC:             0.7074
AUPR:              0.8122
```



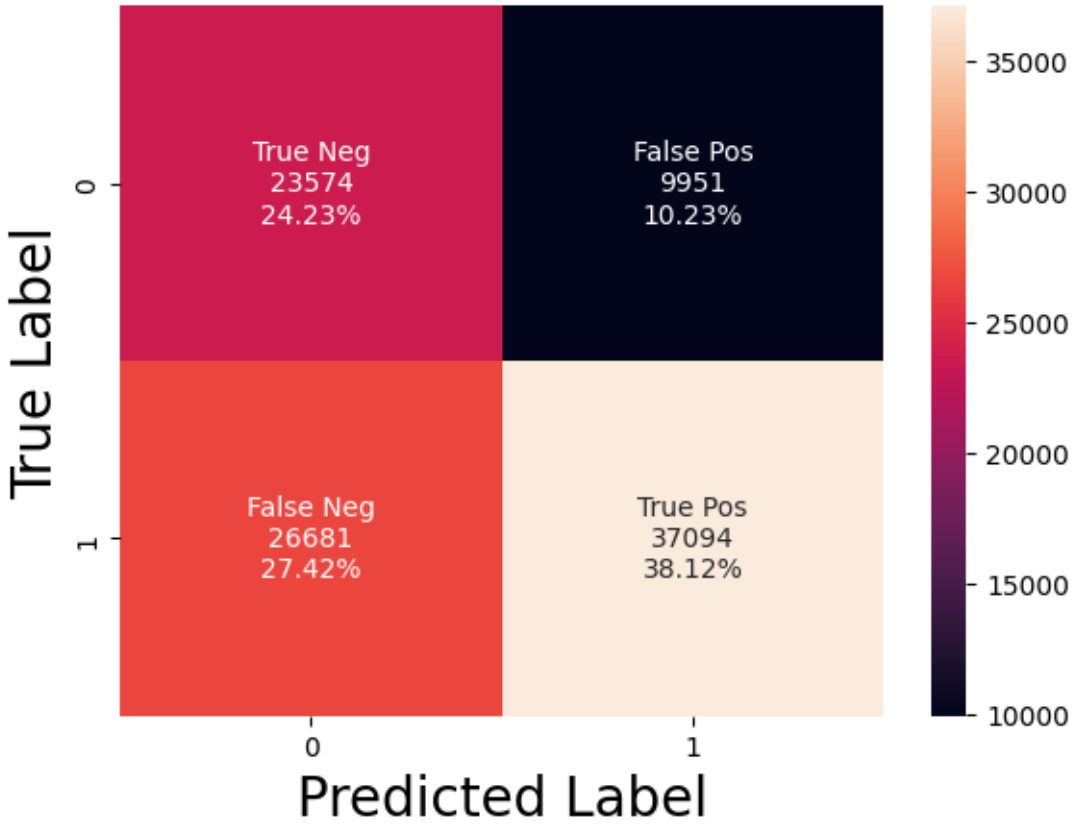
5.3.6 Experimento6

[ ]:
```
gb_clf = GradientBoostingClassifier(learning_rate=0.05)

model_file = GB_MODEL_PATH+"6"
if not exists(model_file):
    gb_clf.fit(x_train, y_train)
    with open(model_file, 'wb') as file:
        pickle.dump(gb_clf,file)
else:
    print("Model was already trained")
    with open(model_file, 'rb') as file:
        gb_clf = pickle.load(file)

gb_pred_class = gb_clf.predict(x_test)
gb_pred_scores = gb_clf.predict_proba(x_test)
accuracy, recall, precision, f1, auroc, aupr = metrics.
 ↪compute_performance_metrics(y_test, gb_pred_class, gb_pred_scores)
metrics.print_metrics_summary(accuracy, recall, precision, f1, auroc, aupr)
metrics.plot_confusion_matrix(y_test, gb_pred_class)
```

```
Model was already trained
```



```
Accuracy:       0.6235
Recall:         0.5816
Precision:      0.7885
F1:             0.6694
AUROC:          0.6982
AUPR:           0.8056
```

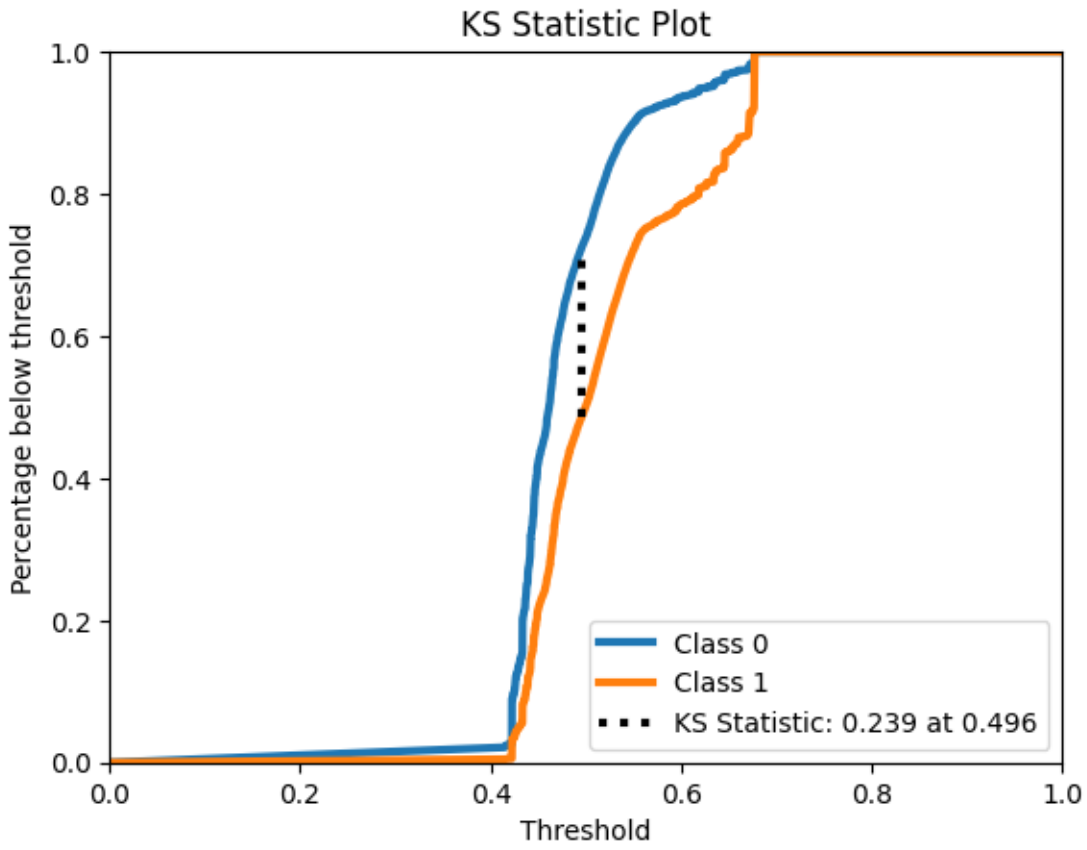


5.3.7 Experimento7

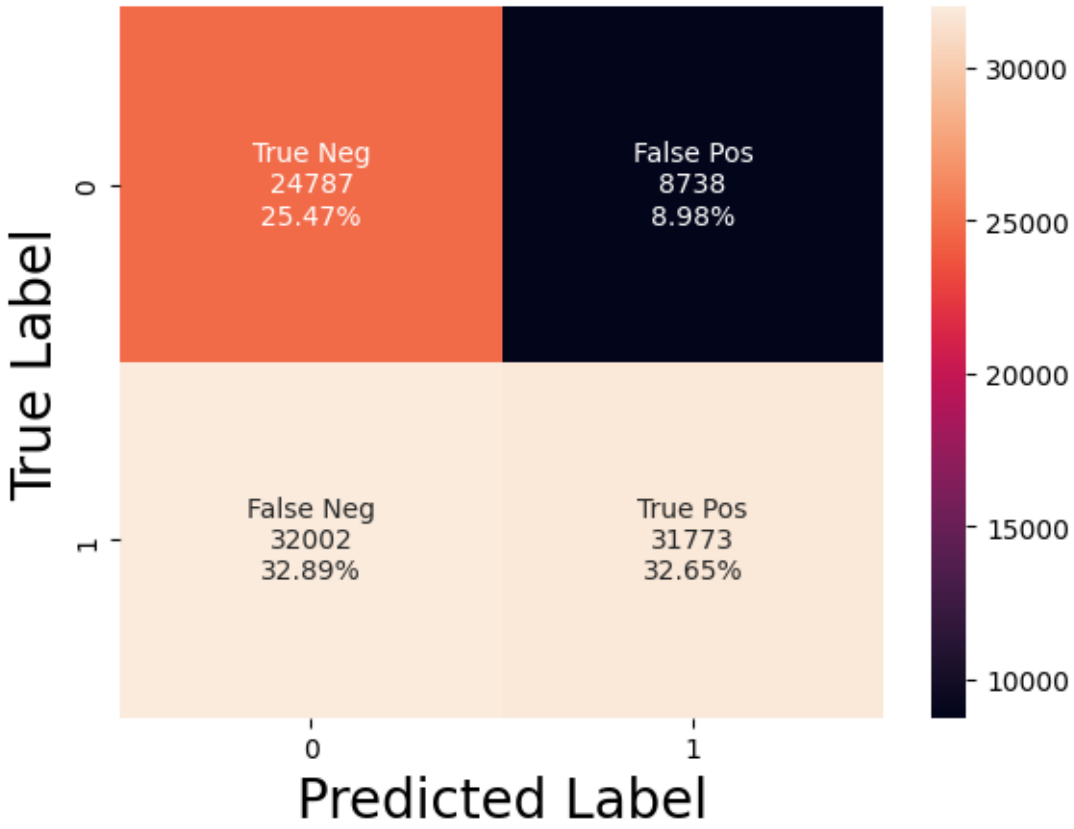
[ ]:
```
gb_clf = GradientBoostingClassifier(learning_rate=0.01)

model_file = GB_MODEL_PATH+"7"
if not exists(model_file):
    gb_clf.fit(x_train, y_train)
    with open(model_file, 'wb') as file:
        pickle.dump(gb_clf,file)
else:
    print("Model was already trained")
    with open(model_file, 'rb') as file:
```

```
        gb_clf = pickle.load(file)

gb_pred_class = gb_clf.predict(x_test)
gb_pred_scores = gb_clf.predict_proba(x_test)
accuracy, recall, precision, f1, auroc, aupr = metrics.
  ↪compute_performance_metrics(y_test, gb_pred_class, gb_pred_scores)
metrics.print_metrics_summary(accuracy, recall, precision, f1, auroc, aupr)
metrics.plot_confusion_matrix(y_test, gb_pred_class)
```

```
Model was already trained
```




```
Accuracy:       0.5813
Recall:         0.4982
Precision:      0.7843
F1:             0.6093
AUROC:          0.6704
AUPR:           0.7891
```



5.4 Random Forest

[ ]:
```
# CP = f"{os.getcwd()}"
PATH = "Models/RF"
MODEL_FILE = f"{PATH}/model"
```

[ ]:
```
# MODELS_PATH = "drive/MyDrive/neural-networks/Models/RF"

# CP = f"{os.getcwd()}"
# PATH = os.path.join(CP, MODELS_PATH)
# MODEL_FILE = f"{PATH}/model"
```

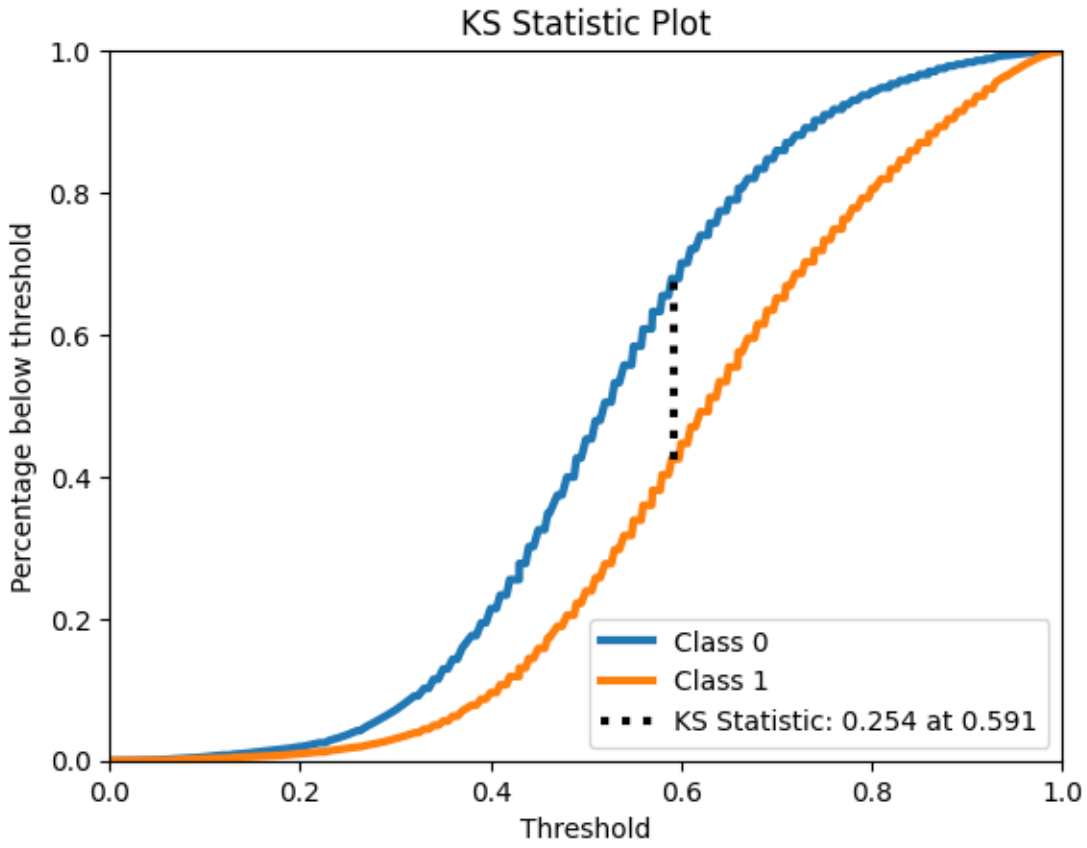
[ ]:
```

```

5.4.1 Experimento1

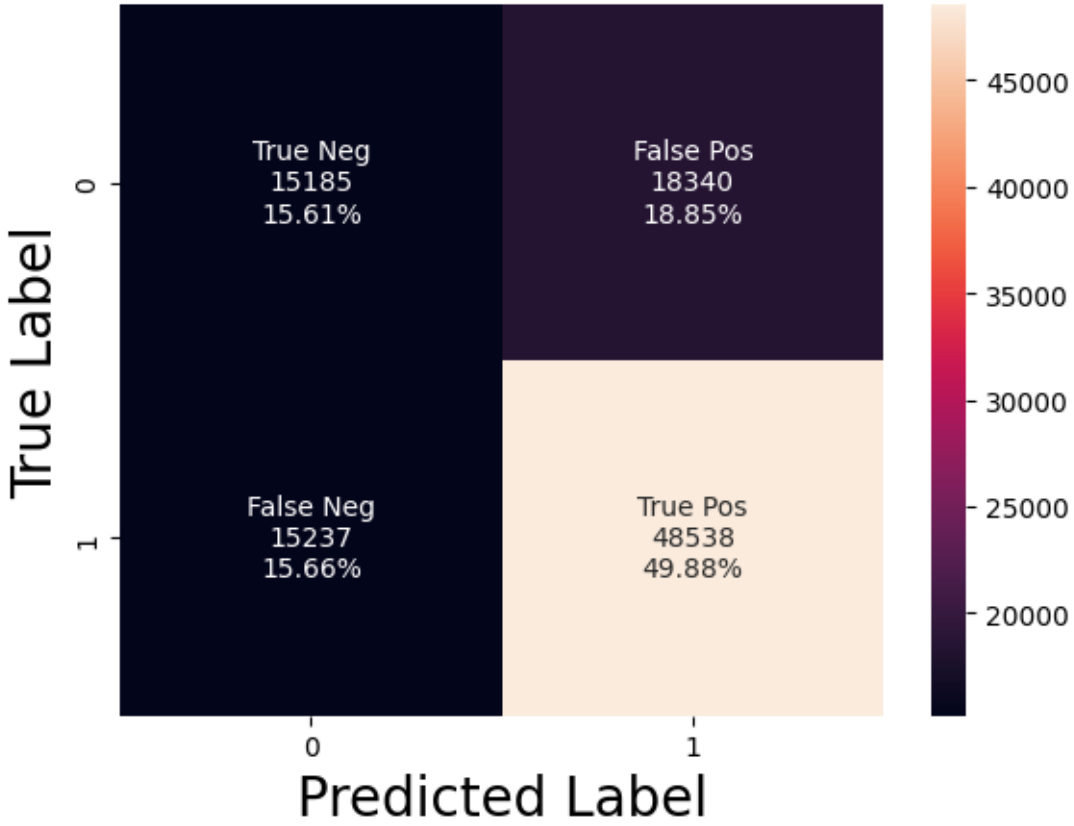
Vamos agora fazer a testagem com todos os parâmetros da RandomForestClassifier nos valores padrão.

[ ]:
```
MODEL_FILE_C = MODEL_FILE + "1.pkl"

rf_clf = RandomForestClassifier()

if not exists(MODEL_FILE_C):
    os.makedirs(PATH, exist_ok = True)
    rf_clf.fit(x_train, y_train)
    pickle.dump(rf_clf, open(MODEL_FILE_C, "wb"))
else:
    print("Model was already trained")

rf_clf = pickle.load(open(MODEL_FILE_C, "rb"))

rf_pred_class = rf_clf.predict(x_test)
rf_pred_scores = rf_clf.predict_proba(x_test)
accuracy, recall, precision, f1, auroc, aupr = metrics.
 ↪compute_performance_metrics(y_test, rf_pred_class, rf_pred_scores)
metrics.print_metrics_summary(accuracy, recall, precision, f1, auroc, aupr)
metrics.plot_confusion_matrix(y_test,rf_pred_class)
```

```
Model was already trained
```



```
Accuracy:       0.6549
Recall:         0.7611
Precision:      0.7258
F1:             0.7430
AUROC:          0.6696
AUPR:           0.7871
```



5.4.2 Experimento2

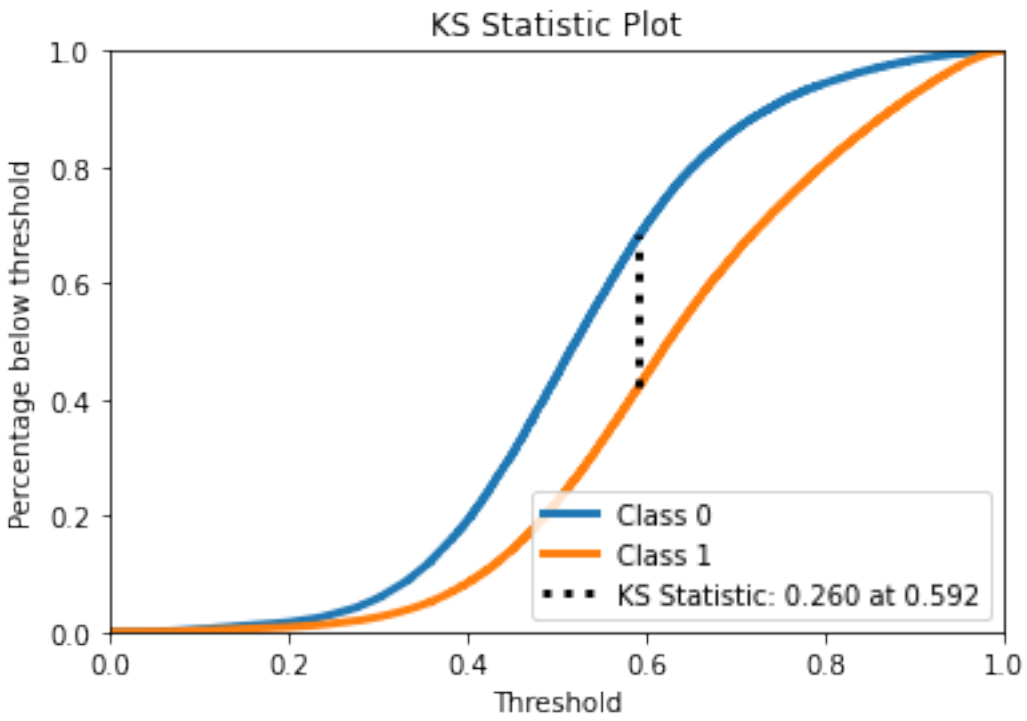
O primeiro parâmetro que irá ser modificado é o parâmetro referente ao número de estimadores.

[ ]:
```
MODEL_FILE_C = MODEL_FILE + "2.pkl"

rf_clf = RandomForestClassifier(n_estimators=500)

if not exists(MODEL_FILE_C):
    os.makedirs(PATH, exist_ok = True)
    rf_clf.fit(x_train, y_train)
```

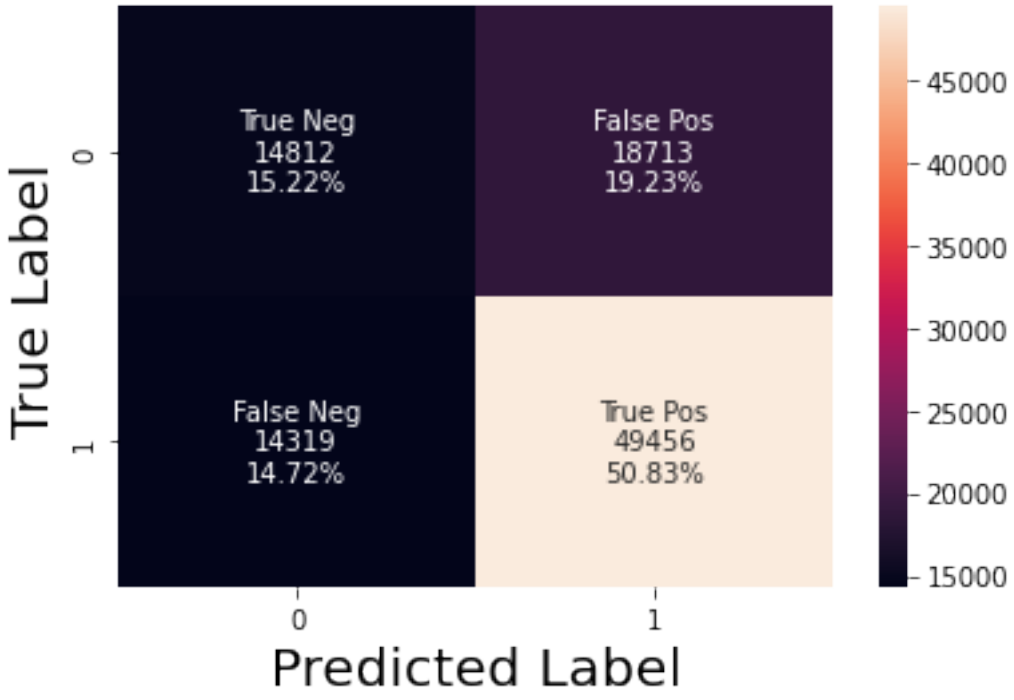
```
    pickle.dump(rf_clf, open(MODEL_FILE_C, "wb"))
else:
    print("Model was already trained")

rf_clf = pickle.load(open(MODEL_FILE_C, "rb"))

rf_pred_class = rf_clf.predict(x_test)
rf_pred_scores = rf_clf.predict_proba(x_test)
accuracy, recall, precision, f1, auroc, aupr = metrics.
 ↪compute_performance_metrics(y_test, rf_pred_class, rf_pred_scores)
metrics.print_metrics_summary(accuracy, recall, precision, f1, auroc, aupr)
metrics.plot_confusion_matrix(y_test,rf_pred_class)
```

```
Model was already trained
```

```
/usr/local/lib/python3.7/dist-packages/sklearn/base.py:338: UserWarning: Trying
to unpickle estimator DecisionTreeClassifier from version 1.1.2 when using
version 1.0.2. This might lead to breaking code or invalid results. Use at your
own risk. For more info please refer to:
https://scikit-learn.org/stable/modules/model_persistence.html#security-
maintainability-limitations
  UserWarning,
/usr/local/lib/python3.7/dist-packages/sklearn/base.py:338: UserWarning: Trying
to unpickle estimator RandomForestClassifier from version 1.1.2 when using
version 1.0.2. This might lead to breaking code or invalid results. Use at your
own risk. For more info please refer to:
https://scikit-learn.org/stable/modules/model_persistence.html#security-
maintainability-limitations
  UserWarning,
```



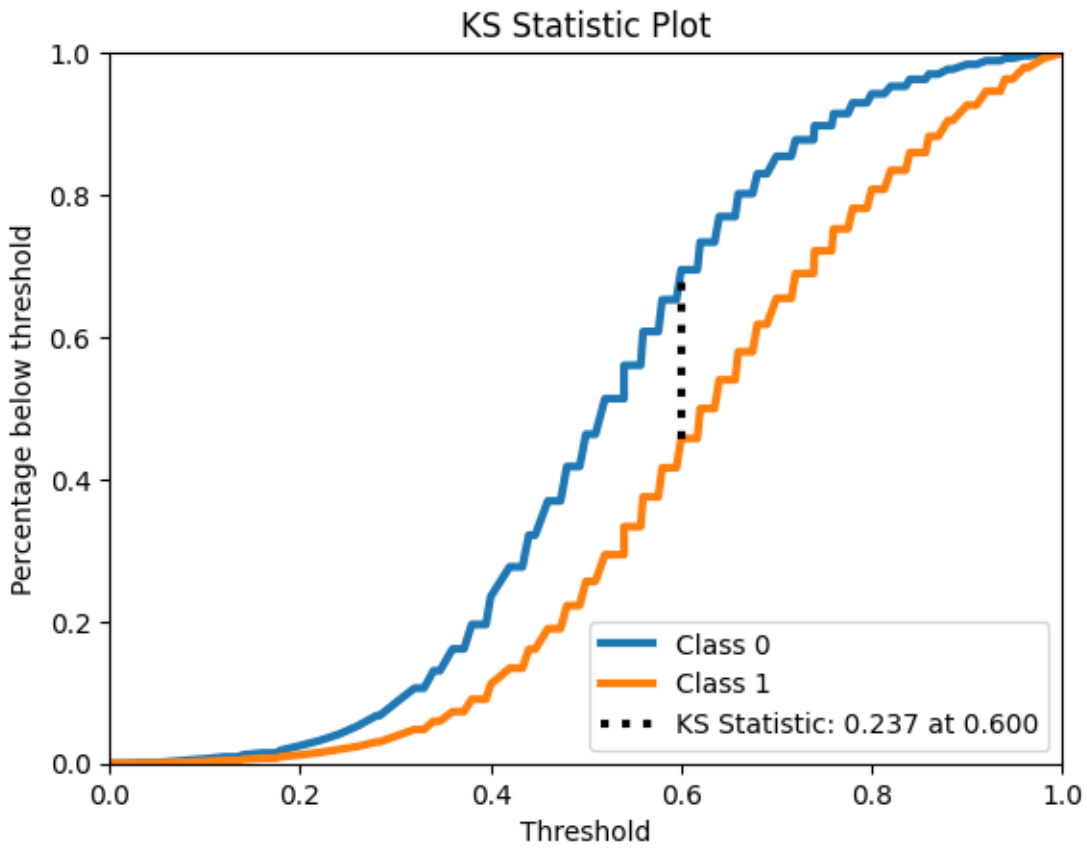

```
Accuracy:          0.6605
Recall:            0.7755
Precision:         0.7255
F1:                0.7497
AUROC:             0.6745
AUPR:              0.7916
```



5.4.3 Experimento3

[ ]:
```
MODEL_FILE_C = MODEL_FILE + "3.pkl"

rf_clf = RandomForestClassifier(n_estimators=50)

if not exists(MODEL_FILE_C):
    os.makedirs(PATH, exist_ok = True)
    rf_clf.fit(x_train, y_train)
    pickle.dump(rf_clf, open(MODEL_FILE_C, "wb"))
else:
    print("Model was already trained")

rf_clf = pickle.load(open(MODEL_FILE_C, "rb"))

rf_pred_class = rf_clf.predict(x_test)
rf_pred_scores = rf_clf.predict_proba(x_test)
accuracy, recall, precision, f1, auroc, aupr = metrics.
  ↪compute_performance_metrics(y_test, rf_pred_class, rf_pred_scores)
metrics.print_metrics_summary(accuracy, recall, precision, f1, auroc, aupr)
metrics.plot_confusion_matrix(y_test,rf_pred_class)
```

```
Model was already trained
```



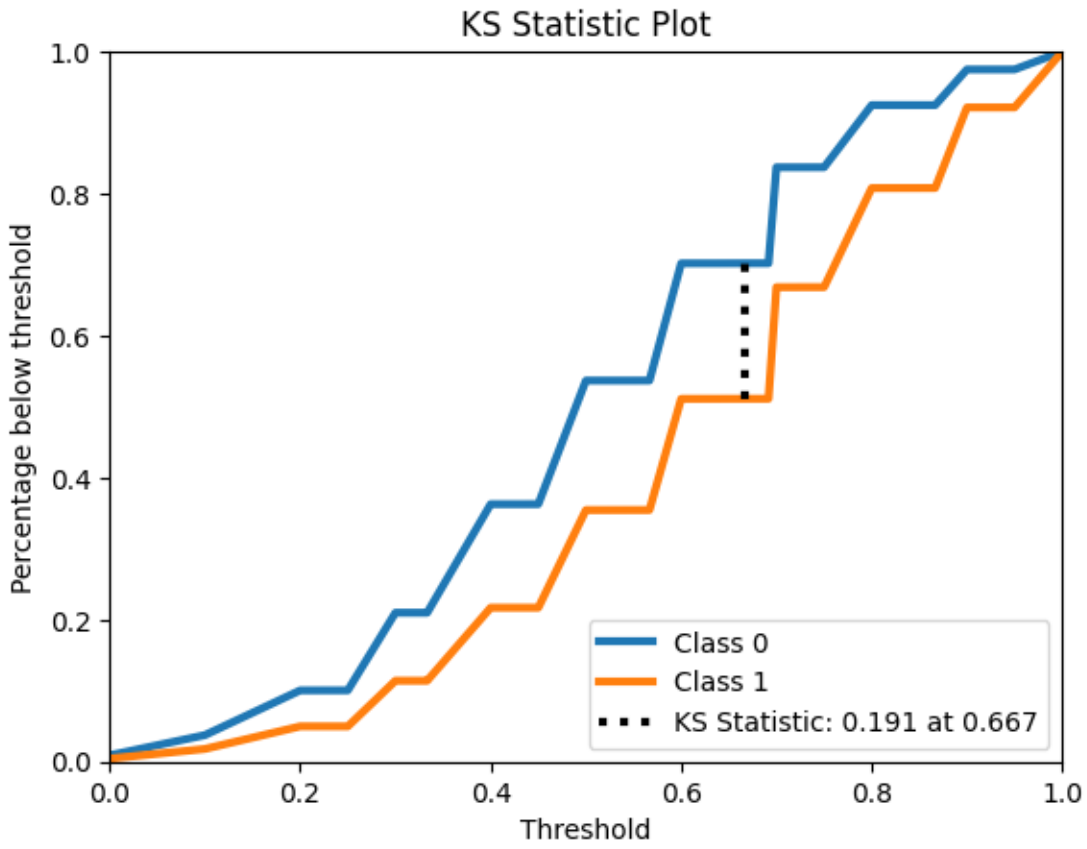
Accuracy:	0.6471
Recall:	0.7437
Precision:	0.7250
F1:	0.7342
AUROC:	0.6618
AUPR:	0.7802

5.4.4 Experimento4

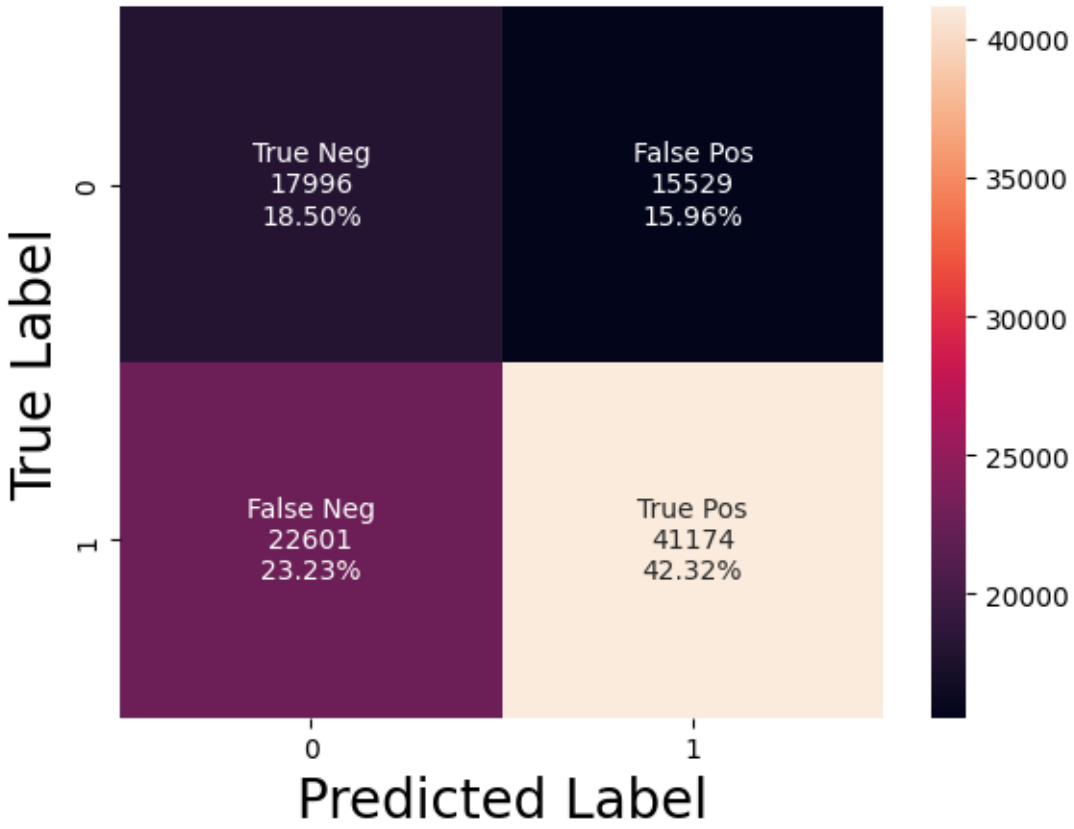
[ ]:
```
MODEL_FILE_C = MODEL_FILE + "4.pkl"

rf_clf = RandomForestClassifier(n_estimators=10)

if not exists(MODEL_FILE_C):
    os.makedirs(PATH, exist_ok = True)
    rf_clf.fit(x_train, y_train)
    pickle.dump(rf_clf, open(MODEL_FILE_C, "wb"))
else:
    print("Model was already trained")

rf_clf = pickle.load(open(MODEL_FILE_C, "rb"))

rf_pred_class = rf_clf.predict(x_test)
rf_pred_scores = rf_clf.predict_proba(x_test)
accuracy, recall, precision, f1, auroc, aupr = metrics.
 ↪compute_performance_metrics(y_test, rf_pred_class, rf_pred_scores)
metrics.print_metrics_summary(accuracy, recall, precision, f1, auroc, aupr)
```

```
metrics.plot_confusion_matrix(y_test,rf_pred_class)
```

```
Model was already trained
```




```
Accuracy:          0.6081
Recall:            0.6456
Precision:         0.7261
F1:                0.6835
AUROC:             0.6302
AUPR:              0.7473
```



5.4.5 Experimento5

```
[ ]: MODEL_FILE_C = MODEL_FILE + "5.pkl"

rf_clf = RandomForestClassifier(n_estimators=1000)

if not exists(MODEL_FILE_C):
    os.makedirs(PATH, exist_ok = True)
    rf_clf.fit(x_train, y_train)
    pickle.dump(rf_clf, open(MODEL_FILE_C, "wb"))
else:
    print("Model was already trained")

rf_clf = pickle.load(open(MODEL_FILE_C, "rb"))

rf_pred_class = rf_clf.predict(x_test)
rf_pred_scores = rf_clf.predict_proba(x_test)
accuracy, recall, precision, f1, auroc, aupr = metrics.
 ↪compute_performance_metrics(y_test, rf_pred_class, rf_pred_scores)
metrics.print_metrics_summary(accuracy, recall, precision, f1, auroc, aupr)
```

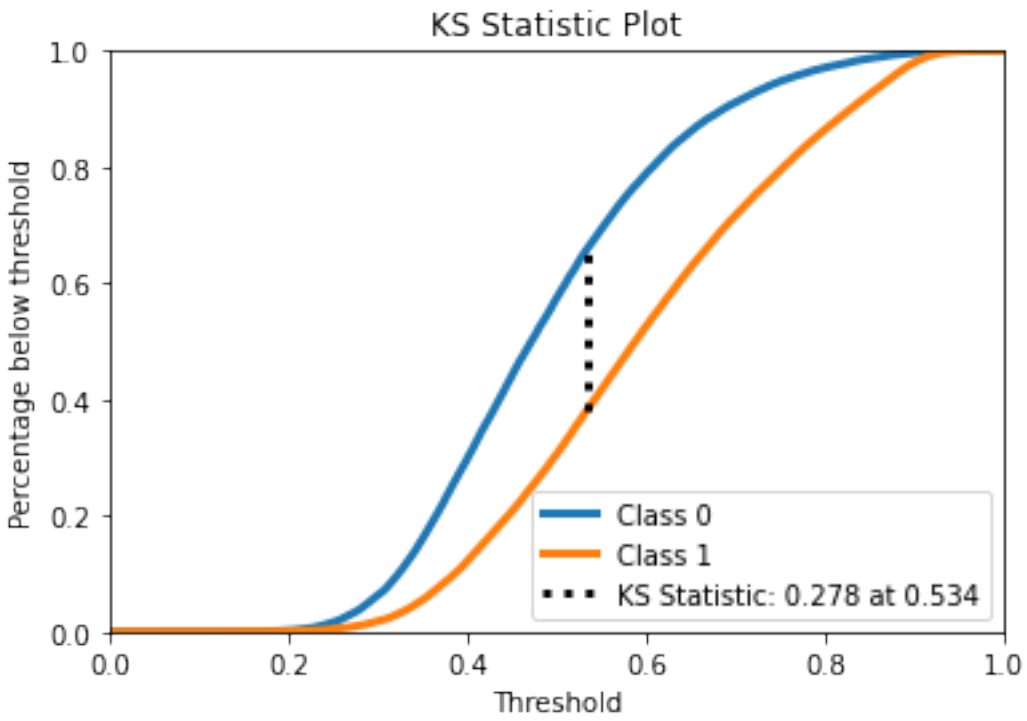
```
metrics.plot_confusion_matrix(y_test,rf_pred_class)
```

```
Model was already trained
```

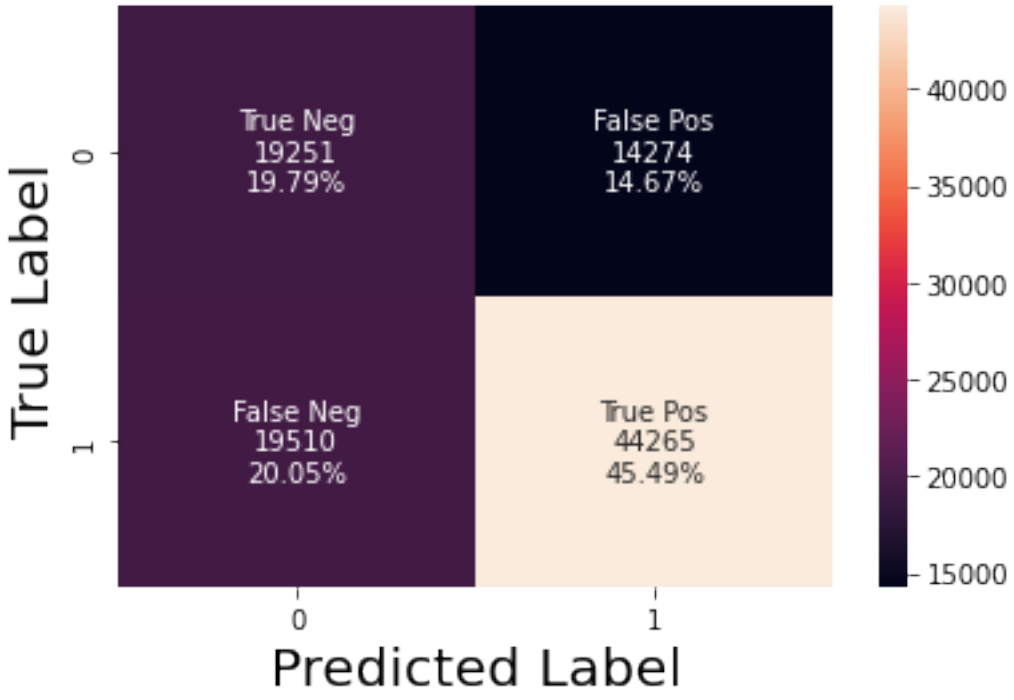
5.4.6 Experimento6

[ ]:
```
MODEL_FILE_C = MODEL_FILE + "6.pkl"

rf_clf = RandomForestClassifier(n_estimators=500, max_depth= 20)

if not exists(MODEL_FILE_C):
    os.makedirs(PATH, exist_ok = True)
    rf_clf.fit(x_train, y_train)
    pickle.dump(rf_clf, open(MODEL_FILE_C, "wb"))
else:
    print("Model was already trained")

rf_clf = pickle.load(open(MODEL_FILE_C, "rb"))

rf_pred_class = rf_clf.predict(x_test)
rf_pred_scores = rf_clf.predict_proba(x_test)
accuracy, recall, precision, f1, auroc, aupr = metrics.
 ↪compute_performance_metrics(y_test, rf_pred_class, rf_pred_scores)
metrics.print_metrics_summary(accuracy, recall, precision, f1, auroc, aupr)
metrics.plot_confusion_matrix(y_test,rf_pred_class)
```

```
Model was already trained
```




```
Accuracy:          0.6528
Recall:            0.6941
Precision:         0.7562
F1:                0.7238
AUROC:             0.6902
AUPR:              0.8032
```

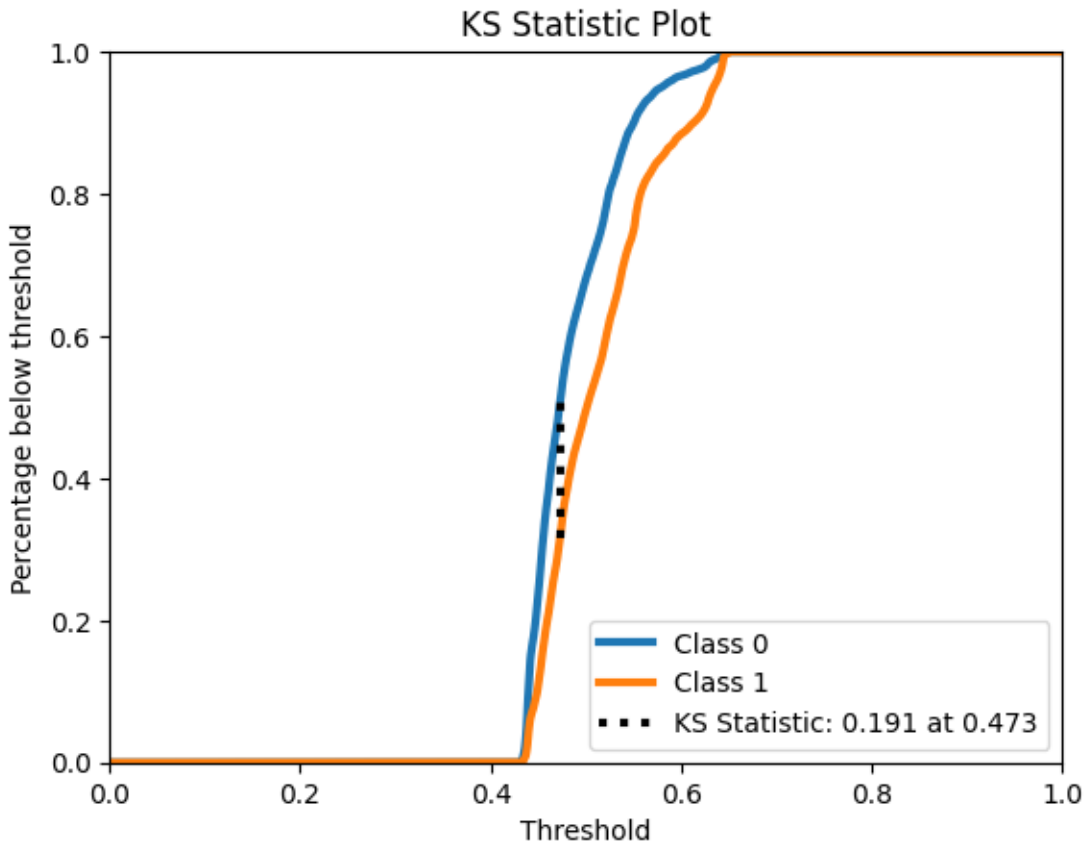


5.4.7 Experimento7

[ ]:
```
MODEL_FILE_C = MODEL_FILE + "7.pkl"

rf_clf = RandomForestClassifier(n_estimators=500, max_depth=2)

if not exists(MODEL_FILE_C):
    os.makedirs(PATH, exist_ok = True)
    rf_clf.fit(x_train, y_train)
    pickle.dump(rf_clf, open(MODEL_FILE_C, "wb"))
else:
    print("Model was already trained")

rf_clf = pickle.load(open(MODEL_FILE_C, "rb"))

rf_pred_class = rf_clf.predict(x_test)
rf_pred_scores = rf_clf.predict_proba(x_test)
accuracy, recall, precision, f1, auroc, aupr = metrics.
 ↪compute_performance_metrics(y_test, rf_pred_class, rf_pred_scores)
metrics.print_metrics_summary(accuracy, recall, precision, f1, auroc, aupr)
metrics.plot_confusion_matrix(y_test,rf_pred_class)
```

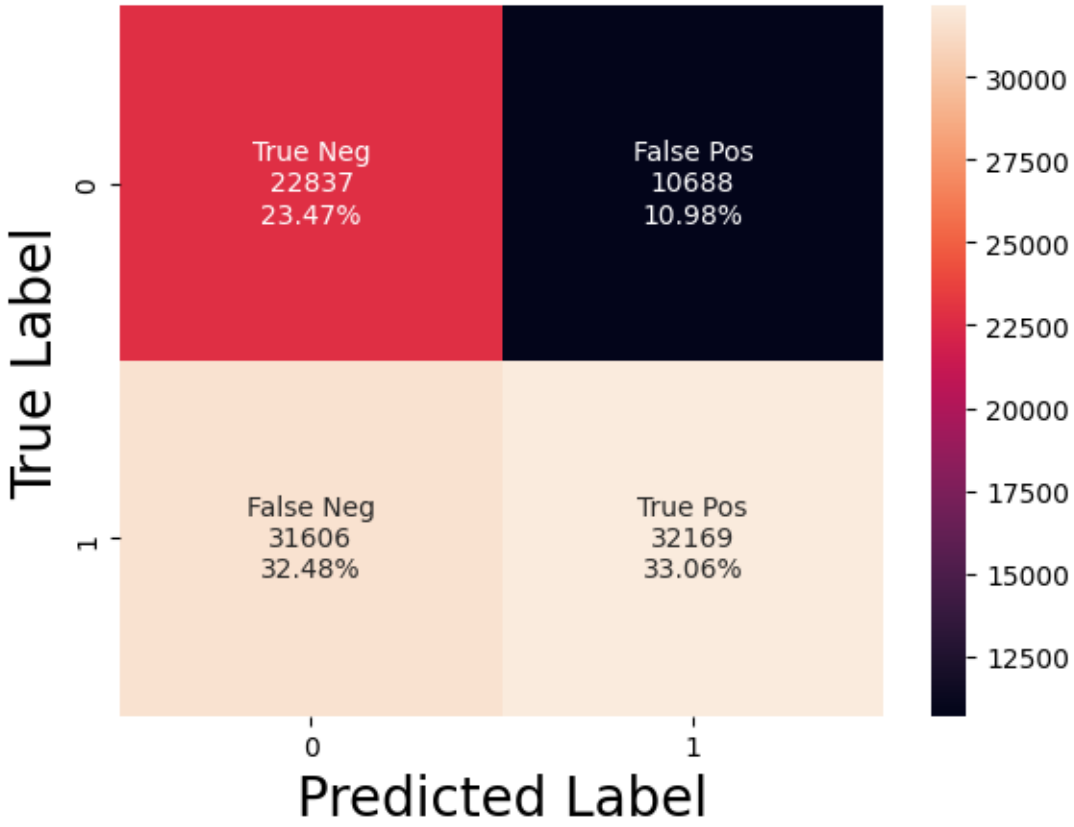
```
Model was already trained
```

```
/home/yesternight/Desktop/neural-networks/neural-networks/lib/python3.10/site-
packages/sklearn/base.py:329: UserWarning: Trying to unpickle estimator
DecisionTreeClassifier from version 1.0.2 when using version 1.1.2. This might
lead to breaking code or invalid results. Use at your own risk. For more info
please refer to:
https://scikit-learn.org/stable/model_persistence.html#security-maintainability-
limitations
  warnings.warn(
/home/yesternight/Desktop/neural-networks/neural-networks/lib/python3.10/site-
packages/sklearn/base.py:329: UserWarning: Trying to unpickle estimator
RandomForestClassifier from version 1.0.2 when using version 1.1.2. This might
lead to breaking code or invalid results. Use at your own risk. For more info
please refer to:
https://scikit-learn.org/stable/model_persistence.html#security-maintainability-
limitations
  warnings.warn(
```




```
Accuracy:          0.5653
Recall:            0.5044
```

```
Precision:          0.7506
F1:                 0.6034
AUROC:              0.6420
AUPR:               0.7680
```

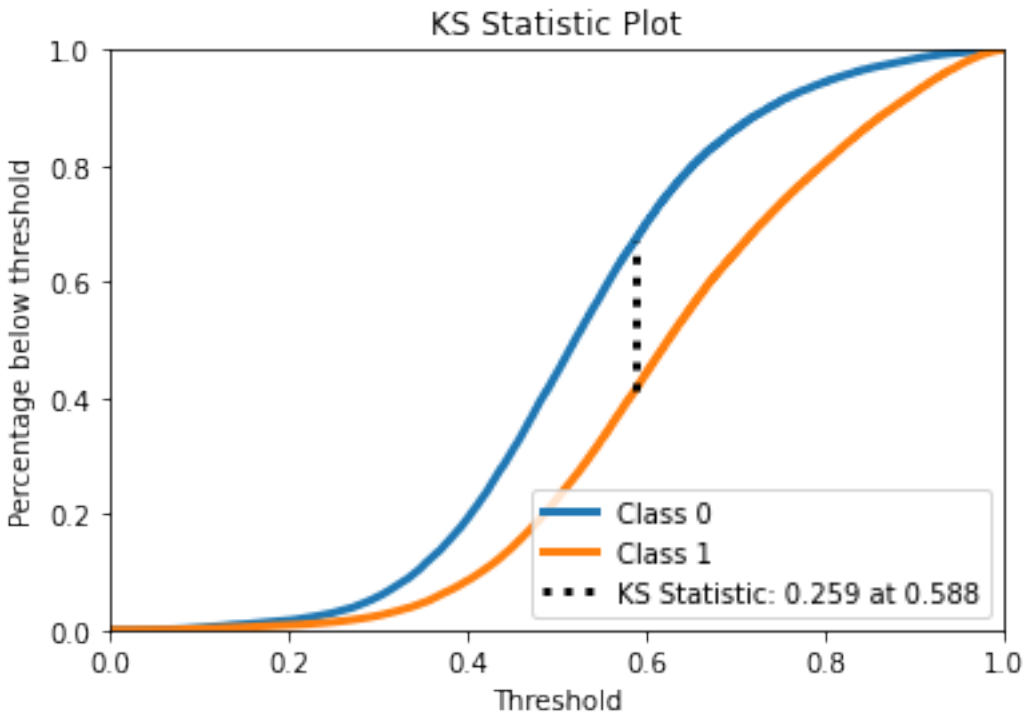


5.4.8 Experimento8

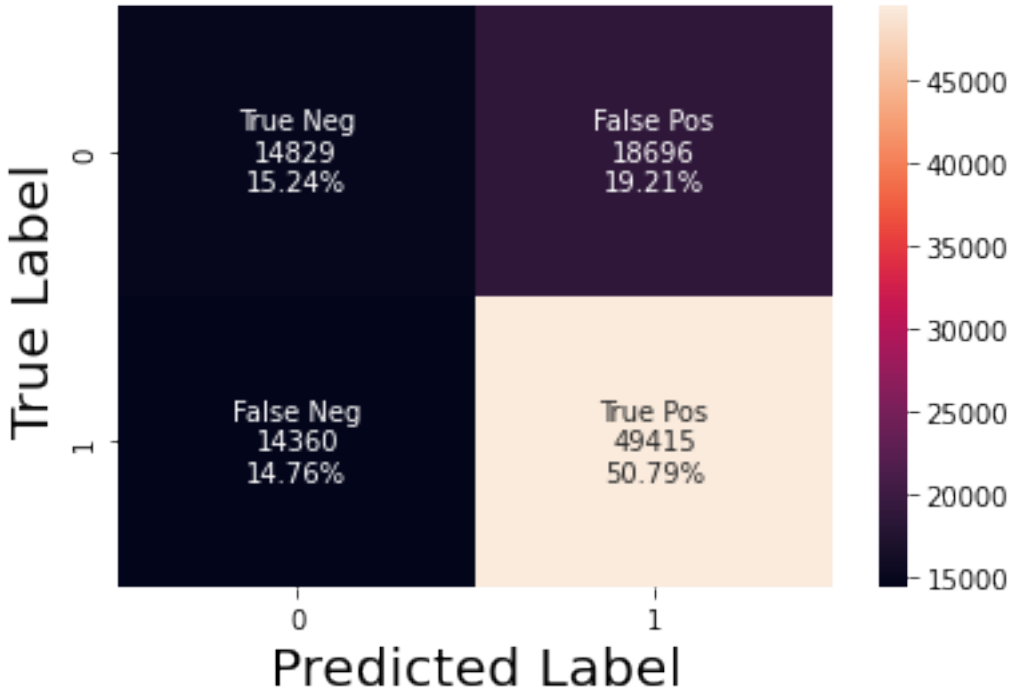
[ ]:
```
MODEL_FILE_C = MODEL_FILE + "8.pkl"

rf_clf = RandomForestClassifier(n_estimators=500, max_depth=40)

if not exists(MODEL_FILE_C):
    os.makedirs(PATH, exist_ok = True)
    rf_clf.fit(x_train, y_train)
    pickle.dump(rf_clf, open(MODEL_FILE_C, "wb"))
else:
    print("Model was already trained")

rf_clf = pickle.load(open(MODEL_FILE_C, "rb"))
```

```
rf_pred_class = rf_clf.predict(x_test)
rf_pred_scores = rf_clf.predict_proba(x_test)
accuracy, recall, precision, f1, auroc, aupr = metrics.
 ↪compute_performance_metrics(y_test, rf_pred_class, rf_pred_scores)
metrics.print_metrics_summary(accuracy, recall, precision, f1, auroc, aupr)
metrics.plot_confusion_matrix(y_test,rf_pred_class)
```

```
Model was already trained
```




```
Accuracy:          0.6603
Recall:            0.7748
Precision:         0.7255
F1:                0.7494
AUROC:             0.6744
AUPR:              0.7922
```



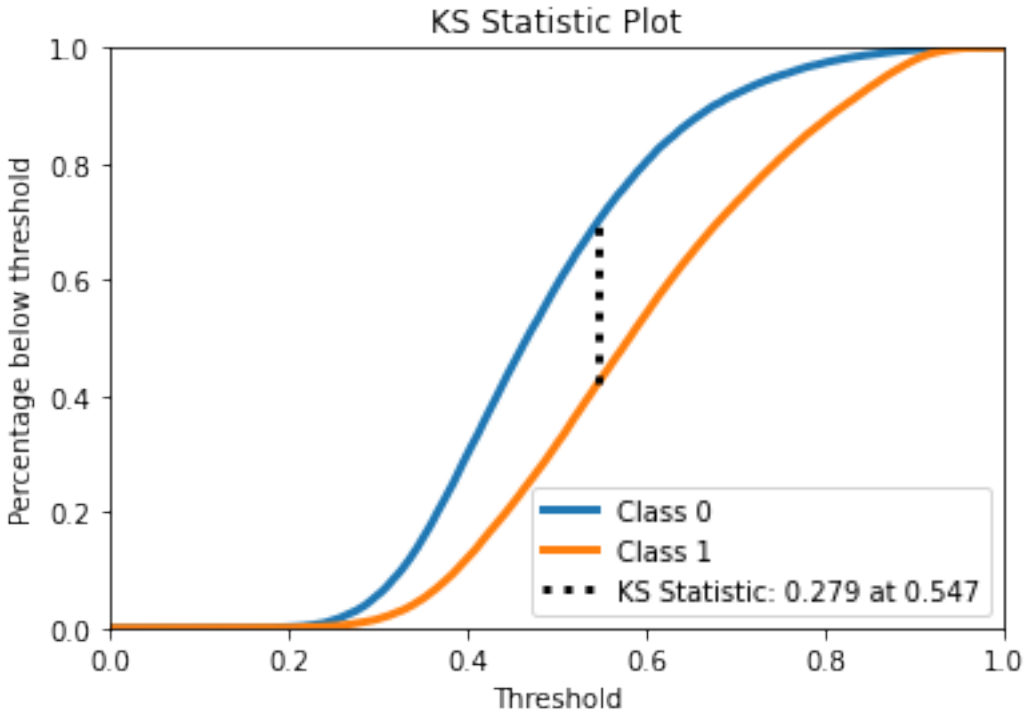
5.4.9 Experimento9

Variando agora o critério de divisão usando o melhor valor do número de estimadores e melhor profundidade máxima.

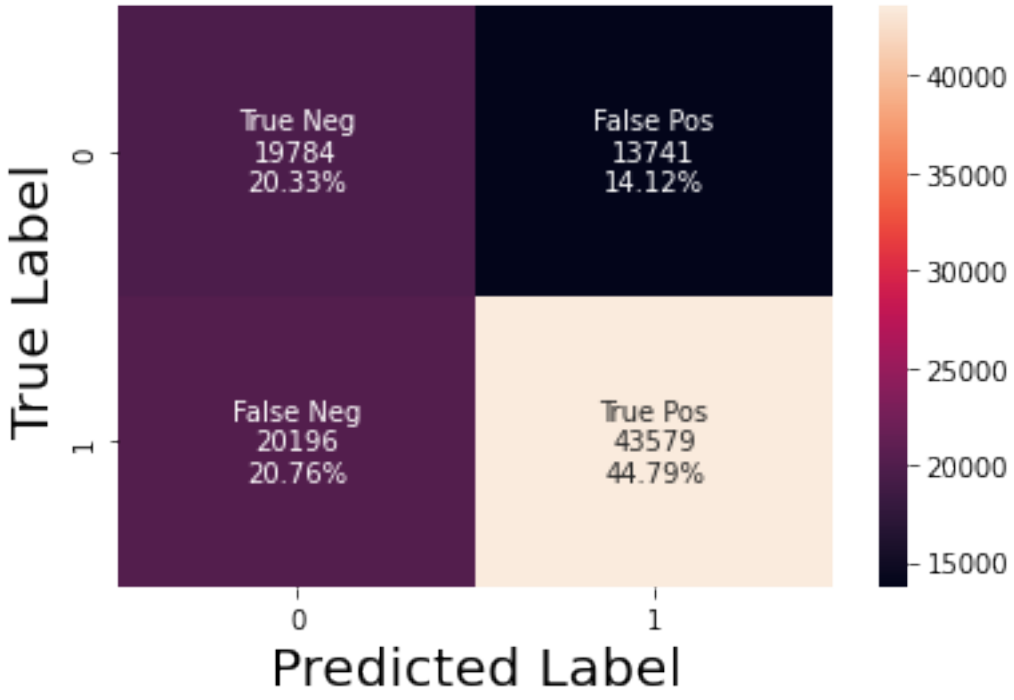
[ ]:
```
MODEL_FILE_C = MODEL_FILE + "9.pkl"

rf_clf = RandomForestClassifier(n_estimators=500, max_depth=20,␣
 ↪criterion="entropy")

if not exists(MODEL_FILE_C):
    os.makedirs(PATH, exist_ok = True)
    rf_clf.fit(x_train, y_train)
    pickle.dump(rf_clf, open(MODEL_FILE_C, "wb"))
else:
    print("Model was already trained")

rf_clf = pickle.load(open(MODEL_FILE_C, "rb"))

rf_pred_class = rf_clf.predict(x_test)
rf_pred_scores = rf_clf.predict_proba(x_test)
accuracy, recall, precision, f1, auroc, aupr = metrics.
 ↪compute_performance_metrics(y_test, rf_pred_class, rf_pred_scores)
metrics.print_metrics_summary(accuracy, recall, precision, f1, auroc, aupr)
```

```
metrics.plot_confusion_matrix(y_test,rf_pred_class)
```

```
Model was already trained
```



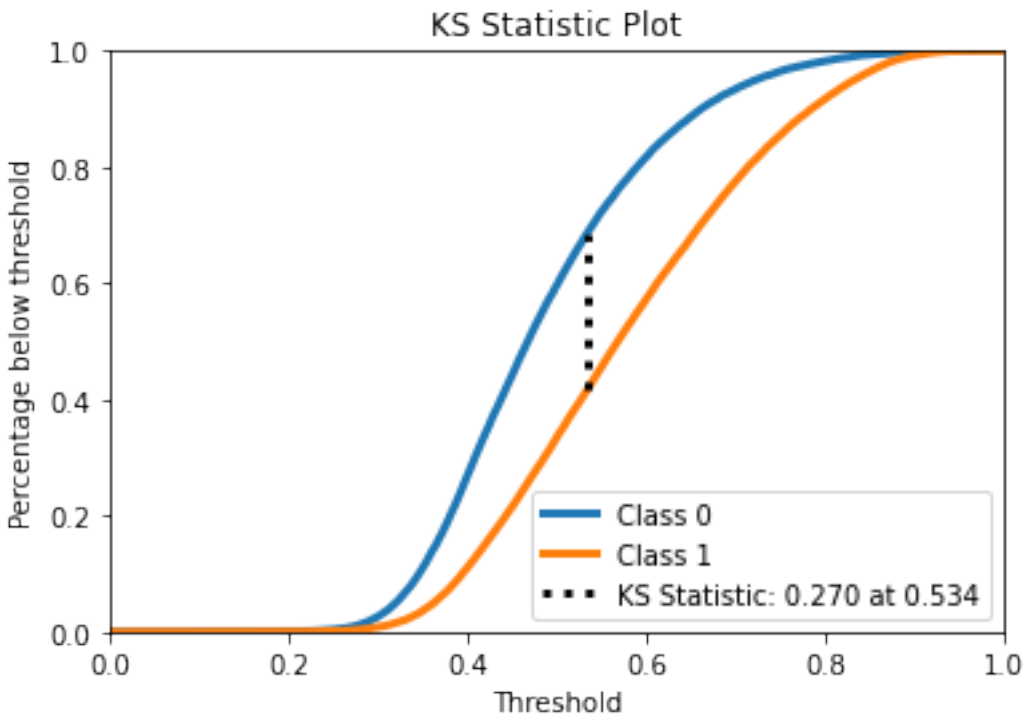

```
Accuracy:          0.6512
Recall:            0.6833
Precision:         0.7603
F1:                0.7197
AUROC:             0.6920
AUPR:              0.8040
```



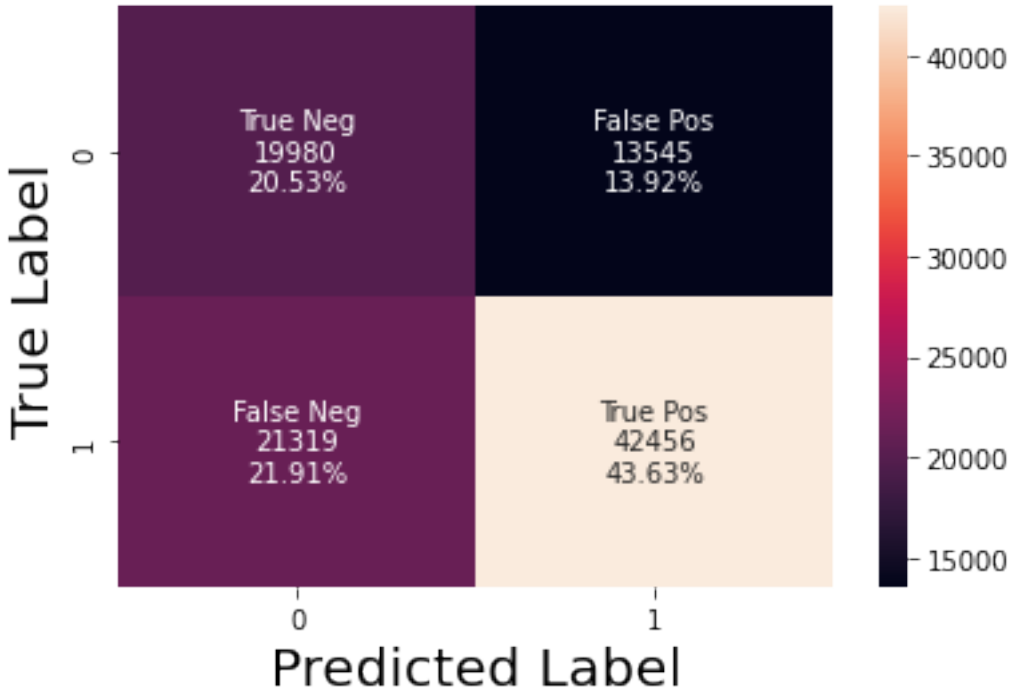
5.4.10 Experimento10

[ ]:
```
MODEL_FILE_C = MODEL_FILE + "10.pkl"

rf_clf = RandomForestClassifier(n_estimators=500, max_depth=20,␣
 ↪criterion="entropy", max_features="log2")

if not exists(MODEL_FILE_C):
    os.makedirs(PATH, exist_ok = True)
    rf_clf.fit(x_train, y_train)
    pickle.dump(rf_clf, open(MODEL_FILE_C, "wb"))
else:
    print("Model was already trained")

rf_clf = pickle.load(open(MODEL_FILE_C, "rb"))

rf_pred_class = rf_clf.predict(x_test)
rf_pred_scores = rf_clf.predict_proba(x_test)
accuracy, recall, precision, f1, auroc, aupr = metrics.
 ↪compute_performance_metrics(y_test, rf_pred_class, rf_pred_scores)
metrics.print_metrics_summary(accuracy, recall, precision, f1, auroc, aupr)
metrics.plot_confusion_matrix(y_test,rf_pred_class)
```

```
Model was already trained
```



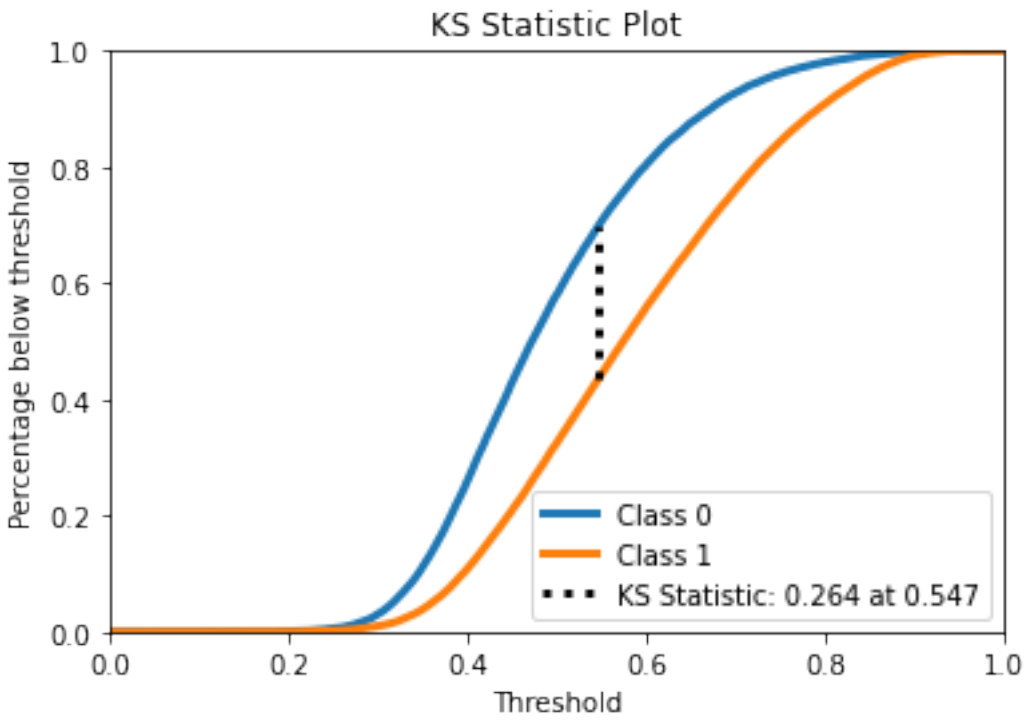

```
Accuracy:          0.6417
Recall:            0.6657
Precision:         0.7581
F1:                0.7089
AUROC:             0.6839
AUPR:              0.7976
```



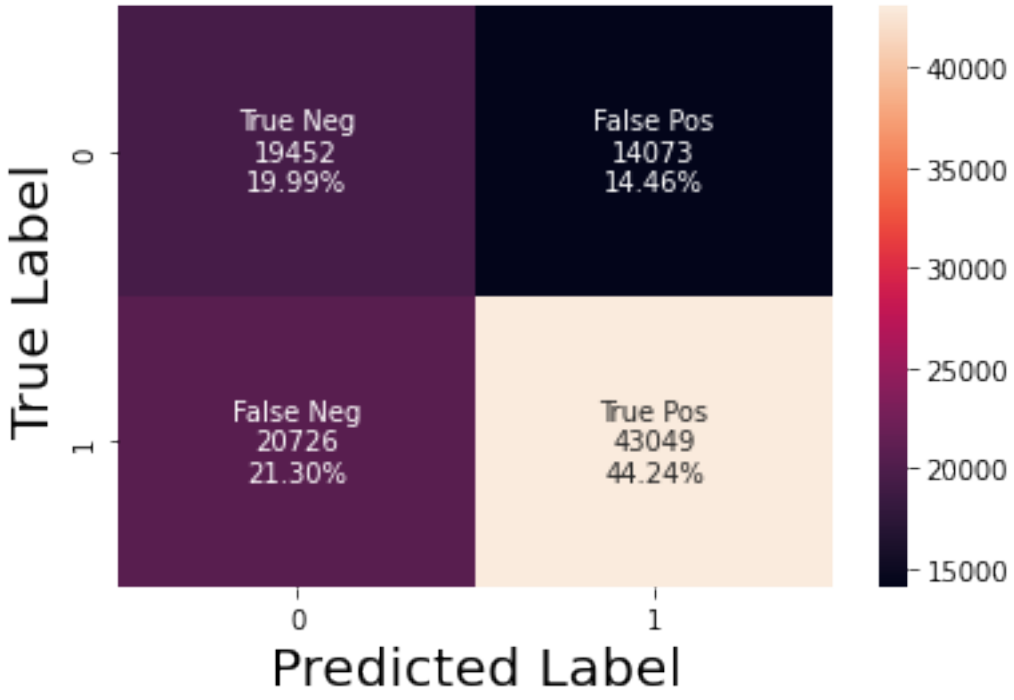
5.4.11 Experimento11

[ ]:
```
MODEL_FILE_C = MODEL_FILE + "11.pkl"

rf_clf = RandomForestClassifier(n_estimators=500, max_depth=20,␣
 ↪max_features="log2")

if not exists(MODEL_FILE_C):
    os.makedirs(PATH, exist_ok = True)
    rf_clf.fit(x_train, y_train)
    pickle.dump(rf_clf, open(MODEL_FILE_C, "wb"))
else:
    print("Model was already trained")

rf_clf = pickle.load(open(MODEL_FILE_C, "rb"))

rf_pred_class = rf_clf.predict(x_test)
rf_pred_scores = rf_clf.predict_proba(x_test)
accuracy, recall, precision, f1, auroc, aupr = metrics.
 ↪compute_performance_metrics(y_test, rf_pred_class, rf_pred_scores)
metrics.print_metrics_summary(accuracy, recall, precision, f1, auroc, aupr)
metrics.plot_confusion_matrix(y_test,rf_pred_class)
```

```
Model was already trained
```




```
Accuracy:          0.6424
Recall:            0.6750
Precision:         0.7536
F1:                0.7122
AUROC:             0.6809
AUPR:              0.7958
```



5.5 Ensemble Misto

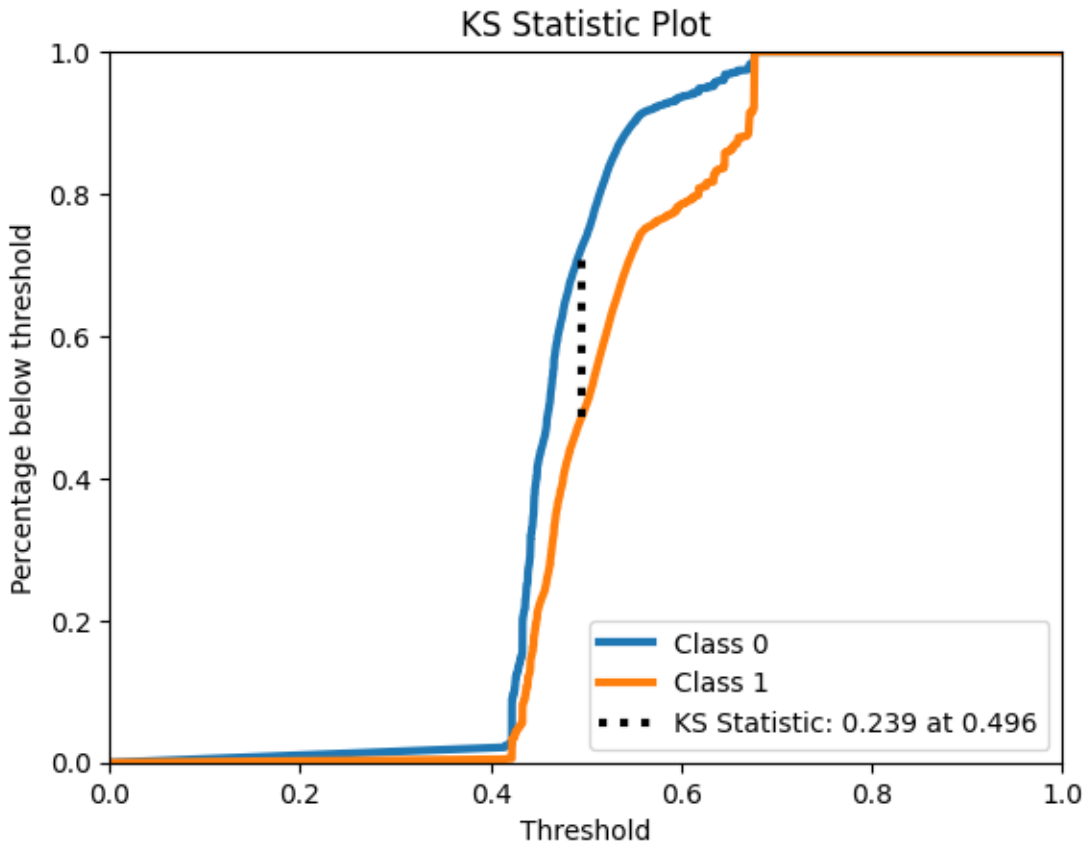
[ ]:
```
MIX_ENS_PATH = "Models/MIX_ENS"
MIX_ENS_MODEL_PATH = f"{MIX_ENS_PATH}/model"
```

5.5.1 Experimento1

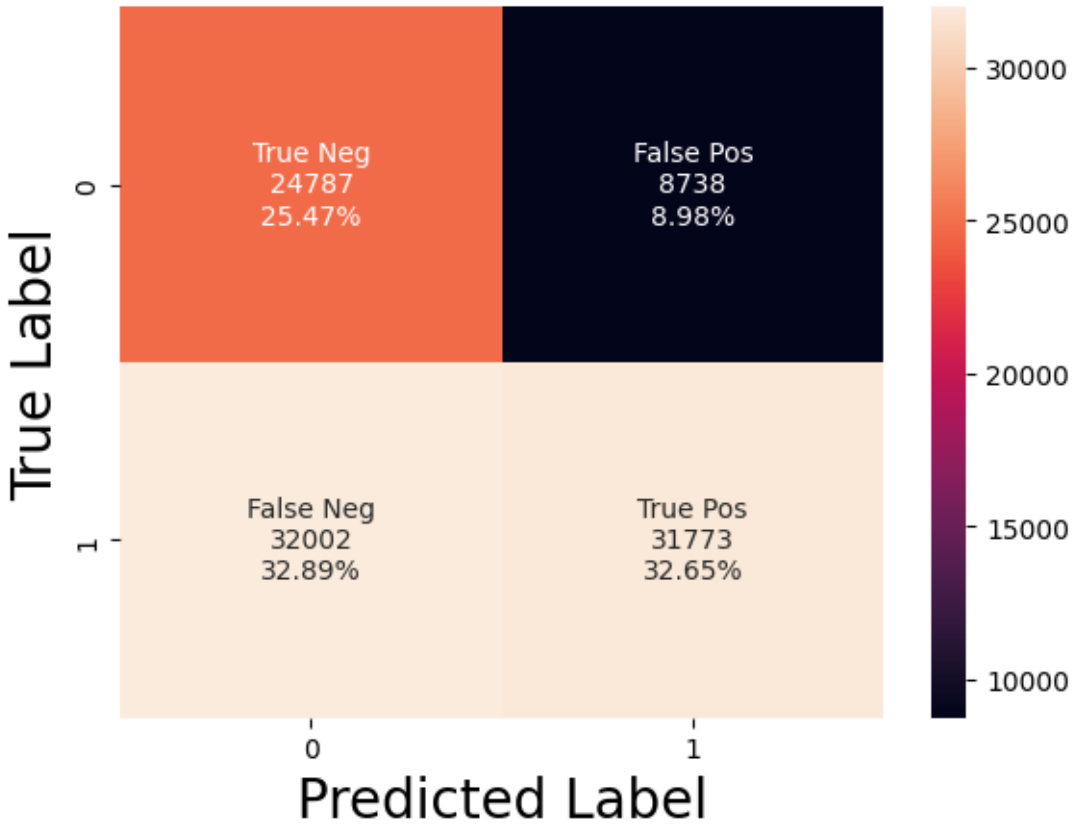
[ ]:
```
gb = GradientBoostingClassifier()
mlp = MLPClassifier()
rf = RandomForestClassifier()

model_file = MIX_ENS_MODEL_PATH+"1"
if not exists(model_file):
    mlp_ens = VotingClassifier([('gb', gb), ('mlp', mlp), ('rf', rf)],␣
 ↪voting='soft')
    mlp_ens.fit(x_train,y_train)
    with open(model_file, 'wb') as file:
        pickle.dump(mlp_ens,file)
else:
    print("Model was already trained")
    with open(model_file, 'rb') as file:
        mlp_ens = pickle.load(file)
```

```
mlp_ens_pred_class = gb_clf.predict(x_test)
mlp_ens_pred_scores = gb_clf.predict_proba(x_test)
accuracy, recall, precision, f1, auroc, aupr = metrics.
  ↪compute_performance_metrics(y_test, mlp_ens_pred_class, mlp_ens_pred_scores)
metrics.print_metrics_summary(accuracy, recall, precision, f1, auroc, aupr)
metrics.plot_confusion_matrix(y_test, mlp_ens_pred_class)
```

```
Model was already trained
```




```
Accuracy:       0.5813
Recall:         0.4982
Precision:      0.7843
F1:             0.6093
AUROC:          0.6704
AUPR:           0.7891
```

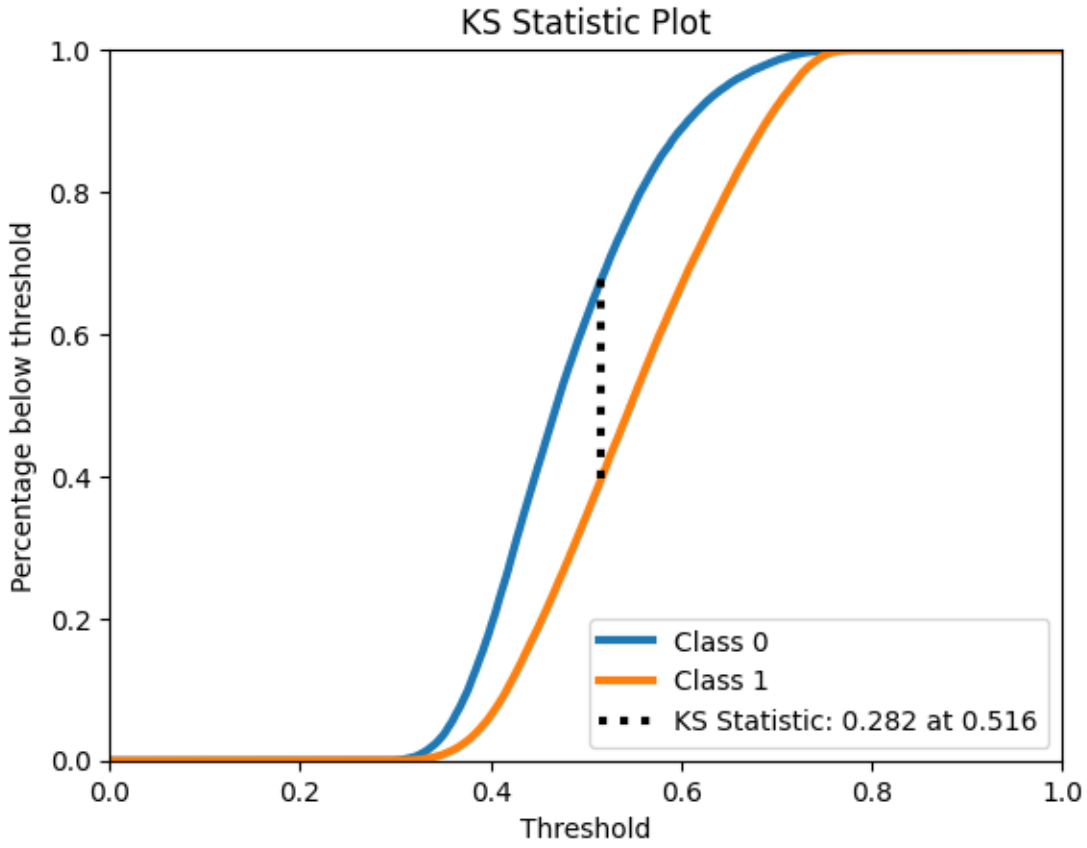


5.6 Experimento2

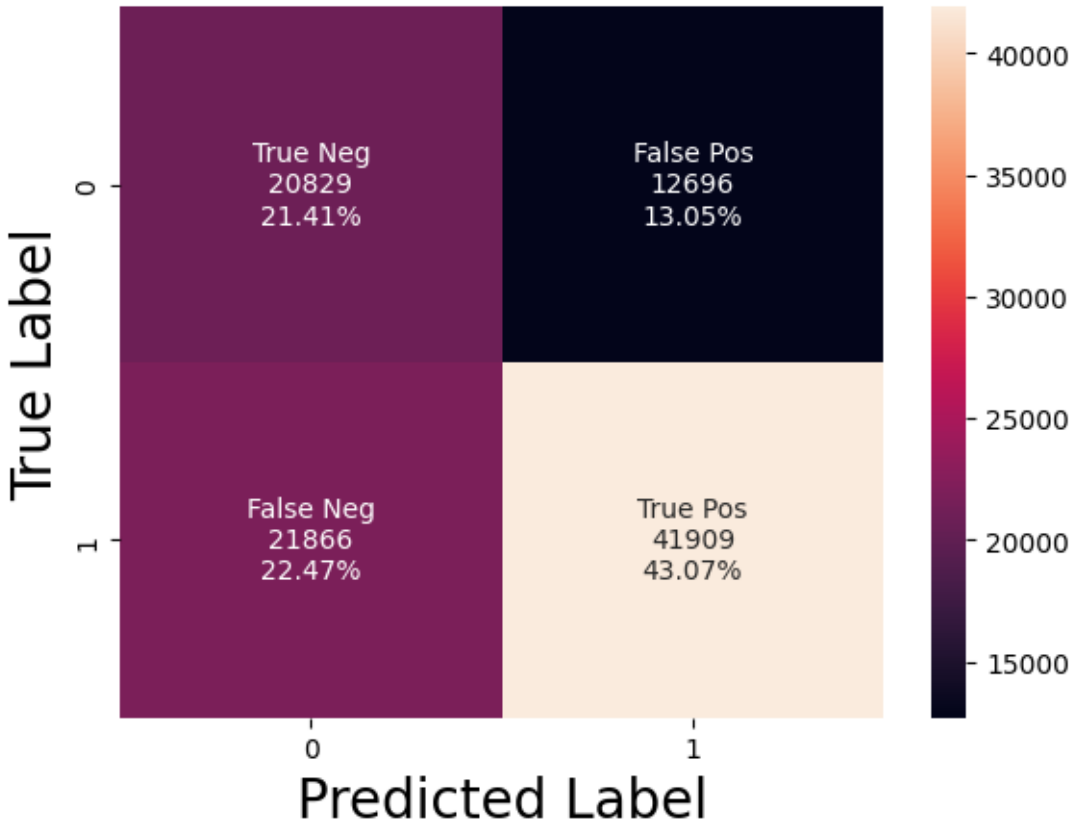
[ ]:
```
gb = GradientBoostingClassifier(n_estimators=10, learning_rate=0.01)
mlp = MLPClassifier(hidden_layer_sizes=(64,64), activation="logistic",␣
 ↪solver="sgd")
rf = RandomForestClassifier(n_estimators=500, max_depth=20, criterion="entropy")

model_file = MIX_ENS_MODEL_PATH+"2"
if not exists(model_file):
    mlp_ens = VotingClassifier([('gb', gb), ('mlp', mlp), ('rf', rf)],␣
 ↪voting='soft')
    mlp_ens.fit(x_train,y_train)
    with open(model_file, 'wb') as file:
        pickle.dump(mlp_ens,file)
else:
    print("Model was already trained")
    with open(model_file, 'rb') as file:
        mlp_ens = pickle.load(file)
```

```
mlp_ens_pred_class = mlp_ens.predict(x_test)
mlp_ens_pred_scores = mlp_ens.predict_proba(x_test)
accuracy, recall, precision, f1, auroc, aupr = metrics.
 ↪compute_performance_metrics(y_test, mlp_ens_pred_class, mlp_ens_pred_scores)
metrics.print_metrics_summary(accuracy, recall, precision, f1, auroc, aupr)
metrics.plot_confusion_matrix(y_test, mlp_ens_pred_class)
```

```
Model was already trained
```




```
Accuracy:          0.6448
Recall:            0.6571
Precision:         0.7675
F1:                0.7080
AUROC:             0.6937
AUPR:              0.8050
```



5.6.1 Experimento3

[ ]:
```
gb = GradientBoostingClassifier(n_estimators=100, learning_rate=0.005)
mlp = MLPClassifier(hidden_layer_sizes=(128,128), activation="logistic",␣
 ↪solver="sgd")
rf = RandomForestClassifier(n_estimators=500, max_depth=30, criterion="entropy")

model_file = MIX_ENS_MODEL_PATH+"3"
if not exists(model_file):
    mlp_ens = VotingClassifier([('gb', gb), ('mlp', mlp), ('rf', rf)],␣
 ↪voting='soft')
    mlp_ens.fit(x_train,y_train)
    with open(model_file, 'wb') as file:
        pickle.dump(mlp_ens,file)
else:
    print("Model was already trained")
    with open(model_file, 'rb') as file:
        mlp_ens = pickle.load(file)
```

```
mlp_ens_pred_class = mlp_ens.predict(x_test)
mlp_ens_pred_scores = mlp_ens.predict_proba(x_test)
metrics.print_metrics_summary(accuracy, recall, precision, f1, auroc, aupr)
metrics.plot_confusion_matrix(y_test, mlp_ens_pred_class)
```

```
Model was already trained
```

5.7 SVM

5.7.1 Experimento 1

[ ]:
```
MODELS_PATH = "Models/SVM"
HISTORY_PATH = f"{MODELS_PATH}/history"
MODEL_PATH = f"{MODELS_PATH}/model"
```

[ ]:
```
model_file = MODEL_PATH + "2"

classifier = SVC(C=1.0, kernel="rbf", probability=True, verbose=True, n_iter_=1)

if  not exists(model_file):
    svm_model = classifier.fit(x_train, y_train)
    outfile = open(model_file, "wb")
    pickle.dump(svm_model, outfile)
    outfile.close()
else:
    print("Model was already trained")
    infile = open(model_file,"rb")
    classifier = pickle.load(infile)
    infile.close()
```

```
[LibSVM]…
```

[ ]:
```
# Fazer predições no conjunto de teste
y_pred_scores = classifier.predict_proba(x_test)
y_pred_class = classifier.predict(x_test)

## Matriz de confusão
print('Matriz de confusão no conjunto de teste:')
metrics.plot_confusion_matrix(y_test, y_pred_class)



## Resumo dos resultados
accuracy, recall, precision, f1, auroc, aupr = metrics.
 ↪compute_performance_metrics(y_test, y_pred_class, y_pred_scores)
print('Performance no conjunto de validação:')
```

```
metrics.print_metrics_summary(accuracy, recall, precision, f1, auroc, aupr)
```