IoT_Botnet_Detection-LSTM

June 23, 2023

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2 1. DDoS Detection on IoT - Unique Model - L5 - 23 Features - LSTM

2.1 1.1 Imports

[1]:

```
import os
os.environ['PYTHONHASHSEED'] = '0'
os.environ["CUDA_VISIBLE_DEVICES"]="-1"
os.environ["TF_CUDNN_USE_AUTOTUNE"]="0"

import numpy as np
np.random.seed(2023)

import random as rn
rn.seed(2023)

import pandas as pd
import matplotlib.pyplot as plt
%matplotlib inline

from datetime import datetime
import time

import tensorflow as tf
tf.random.set_seed(2023)
from tensorflow import keras

from sklearn.preprocessing import MinMaxScaler
from sklearn.metrics import classification_report, accuracy_score
from sklearn.metrics import confusion_matrix
from sklearn.metrics import ConfusionMatrixDisplay

import warnings
warnings.filterwarnings('ignore')

from IPython.display import set_matplotlib_formats
set_matplotlib_formats('pdf', 'svg')

import seaborn as sns
# sns.set(color_codes=True)

from keras.layers import Input, Dropout, Dense, LSTM, TimeDistributed,␣
  ↪RepeatVector
from keras.models import Model
from keras import regularizers

import json, codecs
```

```
2023-06-22 09:42:11.696610: I tensorflow/tsl/cuda/cudart_stub.cc:28] Could not
find cuda drivers on your machine, GPU will not be used.
2023-06-22 09:42:11.742599: I tensorflow/tsl/cuda/cudart_stub.cc:28] Could not
find cuda drivers on your machine, GPU will not be used.
2023-06-22 09:42:11.743768: I tensorflow/core/platform/cpu_feature_guard.cc:182]
This TensorFlow binary is optimized to use available CPU instructions in
performance-critical operations.
To enable the following instructions: AVX2 FMA, in other operations, rebuild
TensorFlow with the appropriate compiler flags.
2023-06-22 09:42:12.784296: W
tensorflow/compiler/tf2tensorrt/utils/py_utils.cc:38] TF-TRT Warning: Could not
find TensorRT
```

3 2. Import Datasets and Normalize

3.1 2.1 Danmini Doorbell

[2]:

```
# Benign traffic

dd_benign = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Danmini_Doorbell/benign_traffic.csv', encoding = "utf-8", sep = ',' )
df_dd_benign = dd_benign.copy(deep=True)

columns = list(df_dd_benign.columns)
chosen_columns = []

for column in columns:
    if column.find('L5') != -1:             # selecionando apenas intervalo L5␣
 ↪(100 ms)
        chosen_columns.append(column)

df_dd_benign = pd.DataFrame(df_dd_benign, columns = chosen_columns)

# Mirai attacks
dd_mirai_ack = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Danmini_Doorbell/mirai_attacks/ack.csv', encoding = "utf-8", sep = ',' )
df_dd_mirai_ack = dd_mirai_ack.copy(deep=True)
df_dd_mirai_ack = pd.DataFrame(df_dd_mirai_ack, columns = chosen_columns)

dd_mirai_scan = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Danmini_Doorbell/mirai_attacks/scan.csv', encoding = "utf-8", sep = ',' )
df_dd_mirai_scan = dd_mirai_scan.copy(deep=True)
df_dd_mirai_scan = pd.DataFrame(df_dd_mirai_scan, columns = chosen_columns)

dd_mirai_syn = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Danmini_Doorbell/mirai_attacks/syn.csv', encoding = "utf-8", sep = ',' )
df_dd_mirai_syn = dd_mirai_syn.copy(deep=True)
df_dd_mirai_syn = pd.DataFrame(df_dd_mirai_syn, columns = chosen_columns)

dd_mirai_udp = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Danmini_Doorbell/mirai_attacks/udp.csv', encoding = "utf-8", sep = ',' )
df_dd_mirai_udp = dd_mirai_udp.copy(deep=True)
df_dd_mirai_udp = pd.DataFrame(df_dd_mirai_udp, columns = chosen_columns)

dd_mirai_udpplain = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Danmini_Doorbell/mirai_attacks/udpplain.csv', encoding = "utf-8", sep = ',' )
df_dd_mirai_udpplain = dd_mirai_udpplain.copy(deep=True)
df_dd_mirai_udpplain = pd.DataFrame(df_dd_mirai_udpplain, columns =␣
 ↪chosen_columns)
```

```
# Bashlite attacks
dd_bashlite_combo = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Danmini_Doorbell/gafgyt_attacks/combo.csv', encoding = "utf-8", sep = ',' )
df_dd_bashlite_combo = dd_bashlite_combo.copy(deep=True)
df_dd_bashlite_combo = pd.DataFrame(df_dd_bashlite_combo, columns =␣
 ↪chosen_columns)

dd_bashlite_junk = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Danmini_Doorbell/gafgyt_attacks/junk.csv', encoding = "utf-8", sep = ',' )
df_dd_bashlite_junk = dd_bashlite_junk.copy(deep=True)
df_dd_bashlite_junk = pd.DataFrame(df_dd_bashlite_junk, columns =␣
 ↪chosen_columns)

dd_bashlite_scan = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Danmini_Doorbell/gafgyt_attacks/scan.csv', encoding = "utf-8", sep = ',' )
df_dd_bashlite_scan = dd_bashlite_scan.copy(deep=True)
df_dd_bashlite_scan = pd.DataFrame(df_dd_bashlite_scan, columns =␣
 ↪chosen_columns)

dd_bashlite_udp = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Danmini_Doorbell/gafgyt_attacks/udp.csv', encoding = "utf-8", sep = ',' )
df_dd_bashlite_udp = dd_bashlite_udp.copy(deep=True)
df_dd_bashlite_udp = pd.DataFrame(df_dd_bashlite_udp, columns = chosen_columns)

dd_bashlite_tcp = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Danmini_Doorbell/gafgyt_attacks/tcp.csv', encoding = "utf-8", sep = ',' )
df_dd_bashlite_tcp = dd_bashlite_tcp.copy(deep=True)
df_dd_bashlite_tcp = pd.DataFrame(df_dd_bashlite_tcp, columns = chosen_columns)
```

[3]:

```
df_dd_benign.head()
```

[3]:

```
   MI_dir_L5_weight  MI_dir_L5_mean  MI_dir_L5_variance  H_L5_weight  \
0          1.000000       60.000000            0.000000     1.000000
1          1.000000      354.000000            0.000000     1.000000
2          1.857879      360.458980           35.789338     1.857879
3          1.000000      337.000000            0.000000     1.000000
4          1.680223      172.140917        18487.448750     1.680223

    H_L5_mean  H_L5_variance  HH_L5_weight  HH_L5_mean  HH_L5_std  \
0   60.000000       0.000000      1.000000   60.000000   0.000000
1  354.000000       0.000005      1.000000  354.000000   0.002143
2  360.458979      35.789342      1.857879  360.458979   5.982419
3  337.000000       0.000000      1.000000  337.000000   0.000000
4  172.140917   18487.448750      1.000000   60.000000   0.000000

   HH_L5_magnitude  …  HH_jit_L5_weight  HH_jit_L5_mean  HH_jit_L5_variance  \
0        60.000000  …          1.000000    1.505662e+09        0.000000e+00
1       354.000000  …          1.000000    4.980575e+00        4.230000e-07
2       360.458979  …          1.857879    2.323596e+00        6.056226e+00
3       337.000000  …          1.000000    1.505662e+09        0.000000e+00
4       524.399648  …          1.000000    1.505662e+09        0.000000e+00

   HpHp_L5_weight  HpHp_L5_mean  HpHp_L5_std  HpHp_L5_magnitude  \
0        1.000000     60.000000     0.000000          60.000000
1        1.000000    354.000000     0.002143         354.000000
2        1.857879    360.458979     5.982419         360.458979
3        1.000000    337.000000     0.000000         337.000000
4        1.000000     60.000000     0.000000          60.000000

   HpHp_L5_radius  HpHp_L5_covariance  HpHp_L5_pcc
0        0.000000                 0.0          0.0
1        0.000005                 0.0          0.0
2       35.789342                 0.0          0.0
3        0.000000                 0.0          0.0
4        0.000000                 0.0          0.0

[5 rows x 23 columns]
```

[4]:

```
scaler = MinMaxScaler()

df_dd_benign_norm = scaler.fit_transform(df_dd_benign)
df_dd_miraiack_norm = scaler.fit_transform(df_dd_mirai_ack)
df_dd_miraiscan_norm = scaler.fit_transform(df_dd_mirai_scan)
df_dd_miraisyn_norm = scaler.fit_transform(df_dd_mirai_syn)
df_dd_miraiudp_norm = scaler.fit_transform(df_dd_mirai_udp)
df_dd_miraiudpplain_norm = scaler.fit_transform(df_dd_mirai_udpplain)

df_dd_bashlitecombo_norm = scaler.fit_transform(df_dd_bashlite_combo)
df_dd_bashlitejunk_norm = scaler.fit_transform(df_dd_bashlite_junk)
df_dd_bashlitescan_norm = scaler.fit_transform(df_dd_bashlite_scan)
df_dd_bashliteudp_norm = scaler.fit_transform(df_dd_bashlite_udp)
df_dd_bashlitetcp_norm = scaler.fit_transform(df_dd_bashlite_tcp)
```

3.2 2.2 Ecobee Thermostat

[5]:

```
# Benign traffic

et_benign = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Ecobee_Thermostat/benign_traffic.csv', encoding = "utf-8", sep = ',' )
df_et_benign = et_benign.copy(deep=True)
df_et_benign = pd.DataFrame(df_et_benign, columns = chosen_columns)

# Mirai
```

```
et_mirai_ack = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/Ecobee_Thermostat/mirai_attacks/ack.csv', encoding = "utf-8", sep = ',' )
df_et_mirai_ack = et_mirai_ack.copy(deep=True)
df_et_mirai_ack = pd.DataFrame(df_et_mirai_ack, columns = chosen_columns)

et_mirai_scan = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/Ecobee_Thermostat/mirai_attacks/scan.csv', encoding = "utf-8", sep = ',' )
df_et_mirai_scan = et_mirai_scan.copy(deep=True)
df_et_mirai_scan = pd.DataFrame(df_et_mirai_scan, columns = chosen_columns)

et_mirai_syn = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/Ecobee_Thermostat/mirai_attacks/syn.csv', encoding = "utf-8", sep = ',' )
df_et_mirai_syn = et_mirai_syn.copy(deep=True)
df_et_mirai_syn = pd.DataFrame(df_et_mirai_syn, columns = chosen_columns)

et_mirai_udp = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/Ecobee_Thermostat/mirai_attacks/udp.csv', encoding = "utf-8", sep = ',' )
df_et_mirai_udp = et_mirai_udp.copy(deep=True)
df_et_mirai_udp = pd.DataFrame(df_et_mirai_udp, columns = chosen_columns)

et_mirai_udpplain = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/Ecobee_Thermostat/mirai_attacks/udpplain.csv', encoding = "utf-8", sep = ',' )
df_et_mirai_udpplain = et_mirai_udpplain.copy(deep=True)
df_et_mirai_udpplain = pd.DataFrame(df_et_mirai_udpplain, columns = chosen_columns)

# Bashlite

et_bashlite_combo = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/Ecobee_Thermostat/gafgyt_attacks/combo.csv', encoding = "utf-8", sep = ',' )
df_et_bashlite_combo = et_bashlite_combo.copy(deep=True)
df_et_bashlite_combo = pd.DataFrame(df_et_bashlite_combo, columns = chosen_columns)

et_bashlite_junk = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/Ecobee_Thermostat/gafgyt_attacks/junk.csv', encoding = "utf-8", sep = ',' )
df_et_bashlite_junk = et_bashlite_junk.copy(deep=True)
df_et_bashlite_junk = pd.DataFrame(df_et_bashlite_junk, columns = chosen_columns)

et_bashlite_scan = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/Ecobee_Thermostat/gafgyt_attacks/scan.csv', encoding = "utf-8", sep = ',' )
df_et_bashlite_scan = et_bashlite_scan.copy(deep=True)
df_et_bashlite_scan = pd.DataFrame(df_et_bashlite_scan, columns =␣
 ↪chosen_columns)

et_bashlite_udp = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Ecobee_Thermostat/gafgyt_attacks/udp.csv', encoding = "utf-8", sep = ',' )
df_et_bashlite_udp = et_bashlite_udp.copy(deep=True)
df_et_bashlite_udp = pd.DataFrame(df_et_bashlite_udp, columns = chosen_columns)

et_bashlite_tcp = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Ecobee_Thermostat/gafgyt_attacks/tcp.csv', encoding = "utf-8", sep = ',' )
df_et_bashlite_tcp = et_bashlite_tcp.copy(deep=True)
df_et_bashlite_tcp = pd.DataFrame(df_et_bashlite_tcp, columns = chosen_columns)
```

[6]:

```
df_et_benign_norm = scaler.fit_transform(df_et_benign)

df_et_miraiack_norm = scaler.fit_transform(df_et_mirai_ack)
df_et_miraiscan_norm = scaler.fit_transform(df_et_mirai_scan)
df_et_miraisyn_norm = scaler.fit_transform(df_et_mirai_syn)
df_et_miraiudp_norm = scaler.fit_transform(df_et_mirai_udp)
df_et_miraiudpplain_norm = scaler.fit_transform(df_et_mirai_udpplain)

df_et_bashlitecombo_norm = scaler.fit_transform(df_et_bashlite_combo)
df_et_bashlitejunk_norm = scaler.fit_transform(df_et_bashlite_junk)
df_et_bashlitescan_norm = scaler.fit_transform(df_et_bashlite_scan)
df_et_bashliteudp_norm = scaler.fit_transform(df_et_bashlite_udp)
df_et_bashlitetcp_norm = scaler.fit_transform(df_et_bashlite_tcp)
```

3.3 2.3 Ennio Doorbell

[7]:

```
# Benign traffic

ed_benign = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Ennio_Doorbell/benign_traffic.csv', encoding = "utf-8", sep = ',' )
df_ed_benign = ed_benign.copy(deep=True)
df_ed_benign = pd.DataFrame(df_ed_benign, columns = chosen_columns)

# Only Bashlite

ed_bashlite_combo = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Ennio_Doorbell/gafgyt_attacks/combo.csv', encoding = "utf-8", sep = ',' )
df_ed_bashlite_combo = ed_bashlite_combo.copy(deep=True)
df_ed_bashlite_combo = pd.DataFrame(df_ed_bashlite_combo, columns =␣
 ↪chosen_columns)

ed_bashlite_junk = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Ennio_Doorbell/gafgyt_attacks/junk.csv', encoding = "utf-8", sep = ',' )
```

```
df_ed_bashlite_junk = ed_bashlite_junk.copy(deep=True)
df_ed_bashlite_junk = pd.DataFrame(df_ed_bashlite_junk, columns =␣
 ↪chosen_columns)

ed_bashlite_scan = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Ennio_Doorbell/gafgyt_attacks/scan.csv', encoding = "utf-8", sep = ',' )
df_ed_bashlite_scan = ed_bashlite_scan.copy(deep=True)
df_ed_bashlite_scan = pd.DataFrame(df_ed_bashlite_scan, columns =␣
 ↪chosen_columns)

ed_bashlite_udp = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Ennio_Doorbell/gafgyt_attacks/udp.csv', encoding = "utf-8", sep = ',' )
df_ed_bashlite_udp = ed_bashlite_udp.copy(deep=True)
df_ed_bashlite_udp = pd.DataFrame(df_ed_bashlite_udp, columns = chosen_columns)

ed_bashlite_tcp = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Ennio_Doorbell/gafgyt_attacks/tcp.csv', encoding = "utf-8", sep = ',' )
df_ed_bashlite_tcp = ed_bashlite_tcp.copy(deep=True)
df_ed_bashlite_tcp = pd.DataFrame(df_ed_bashlite_tcp, columns = chosen_columns)
```

[8]:

```
df_ed_benign_norm = scaler.fit_transform(df_ed_benign)

df_ed_bashlitecombo_norm = scaler.fit_transform(df_ed_bashlite_combo)
df_ed_bashlitejunk_norm = scaler.fit_transform(df_ed_bashlite_junk)
df_ed_bashlitescan_norm = scaler.fit_transform(df_ed_bashlite_scan)
df_ed_bashliteudp_norm = scaler.fit_transform(df_ed_bashlite_udp)
df_ed_bashlitetcp_norm = scaler.fit_transform(df_ed_bashlite_tcp)
```

3.4 2.4 Philips Baby Monitor

[9]:

```
# Benign traffic

pb_benign = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Philips_B120N10_Baby_Monitor/benign_traffic.csv', encoding = "utf-8", sep =␣
 ↪',' )
df_pb_benign = pb_benign.copy(deep=True)
df_pb_benign = pd.DataFrame(df_pb_benign, columns = chosen_columns)

# Mirai

pb_mirai_ack = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Philips_B120N10_Baby_Monitor/mirai_attacks/ack.csv', encoding = "utf-8", sep␣
 ↪= ',' )
df_pb_mirai_ack = pb_mirai_ack.copy(deep=True)
df_pb_mirai_ack = pd.DataFrame(df_pb_mirai_ack, columns = chosen_columns)
```

```
pb_mirai_scan = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Philips_B120N10_Baby_Monitor/mirai_attacks/scan.csv', encoding = "utf-8",␣
 ↪sep = ',' )
df_pb_mirai_scan = pb_mirai_scan.copy(deep=True)
df_pb_mirai_scan = pd.DataFrame(df_pb_mirai_scan, columns = chosen_columns)

pb_mirai_syn = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Philips_B120N10_Baby_Monitor/mirai_attacks/syn.csv', encoding = "utf-8", sep␣
 ↪= ',' )
df_pb_mirai_syn = pb_mirai_syn.copy(deep=True)
df_pb_mirai_syn = pd.DataFrame(df_pb_mirai_syn, columns = chosen_columns)

pb_mirai_udp = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Philips_B120N10_Baby_Monitor/mirai_attacks/udp.csv', encoding = "utf-8", sep␣
 ↪= ',' )
df_pb_mirai_udp = pb_mirai_udp.copy(deep=True)
df_pb_mirai_udp = pd.DataFrame(df_pb_mirai_udp, columns = chosen_columns)

pb_mirai_udpplain = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Philips_B120N10_Baby_Monitor/mirai_attacks/udpplain.csv', encoding =␣
 ↪"utf-8", sep = ',' )
df_pb_mirai_udpplain = pb_mirai_udpplain.copy(deep=True)
df_pb_mirai_udpplain = pd.DataFrame(df_pb_mirai_udpplain, columns =␣
 ↪chosen_columns)

# Bashlite

pb_bashlite_combo = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Philips_B120N10_Baby_Monitor/gafgyt_attacks/combo.csv', encoding = "utf-8",␣
 ↪sep = ',' )
df_pb_bashlite_combo = pb_bashlite_combo.copy(deep=True)
df_pb_bashlite_combo = pd.DataFrame(df_pb_bashlite_combo, columns =␣
 ↪chosen_columns)

pb_bashlite_junk = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Philips_B120N10_Baby_Monitor/gafgyt_attacks/junk.csv', encoding = "utf-8",␣
 ↪sep = ',' )
df_pb_bashlite_junk = pb_bashlite_junk.copy(deep=True)
df_pb_bashlite_junk = pd.DataFrame(df_pb_bashlite_junk, columns =␣
 ↪chosen_columns)

pb_bashlite_scan = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Philips_B120N10_Baby_Monitor/gafgyt_attacks/scan.csv', encoding = "utf-8",␣
 ↪sep = ',' )
df_pb_bashlite_scan = pb_bashlite_scan.copy(deep=True)
df_pb_bashlite_scan = pd.DataFrame(df_pb_bashlite_scan, columns =␣
 ↪chosen_columns)

pb_bashlite_udp = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Philips_B120N10_Baby_Monitor/gafgyt_attacks/udp.csv', encoding = "utf-8",␣
 ↪sep = ',' )
df_pb_bashlite_udp = pb_bashlite_udp.copy(deep=True)
df_pb_bashlite_udp = pd.DataFrame(df_pb_bashlite_udp, columns = chosen_columns)

pb_bashlite_tcp = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Philips_B120N10_Baby_Monitor/gafgyt_attacks/tcp.csv', encoding = "utf-8",␣
 ↪sep = ',' )
df_pb_bashlite_tcp = pb_bashlite_tcp.copy(deep=True)
df_pb_bashlite_tcp = pd.DataFrame(df_pb_bashlite_tcp, columns = chosen_columns)
```

[10]:

```
df_pb_benign_norm = scaler.fit_transform(df_pb_benign)

df_pb_miraiack_norm = scaler.fit_transform(df_pb_mirai_ack)
df_pb_miraiscan_norm = scaler.fit_transform(df_pb_mirai_scan)
df_pb_miraisyn_norm = scaler.fit_transform(df_pb_mirai_syn)
df_pb_miraiudp_norm = scaler.fit_transform(df_pb_mirai_udp)
df_pb_miraiudpplain_norm = scaler.fit_transform(df_pb_mirai_udpplain)

df_pb_bashlitecombo_norm = scaler.fit_transform(df_pb_bashlite_combo)
df_pb_bashlitejunk_norm = scaler.fit_transform(df_pb_bashlite_junk)
df_pb_bashlitescan_norm = scaler.fit_transform(df_pb_bashlite_scan)
df_pb_bashliteudp_norm = scaler.fit_transform(df_pb_bashlite_udp)
df_pb_bashlitetcp_norm = scaler.fit_transform(df_pb_bashlite_tcp)
```

3.5 2.5 Security Camera

[11]:

```
# Benign traffic

p7_benign = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Provision_PT_737E_Security_Camera/benign_traffic.csv', encoding = "utf-8",␣
 ↪sep = ',' )
df_p7_benign = p7_benign.copy(deep=True)
df_p7_benign = pd.DataFrame(df_p7_benign, columns = chosen_columns)

# Mirai

p7_mirai_ack = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Provision_PT_737E_Security_Camera/mirai_attacks/ack.csv', encoding =␣
 ↪"utf-8", sep = ',' )
df_p7_mirai_ack = p7_mirai_ack.copy(deep=True)
df_p7_mirai_ack = pd.DataFrame(df_p7_mirai_ack, columns = chosen_columns)
```

```
p7_mirai_scan = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Provision_PT_737E_Security_Camera/mirai_attacks/scan.csv', encoding =␣
 ↪"utf-8", sep = ',' )
df_p7_mirai_scan = p7_mirai_scan.copy(deep=True)
df_p7_mirai_scan = pd.DataFrame(df_p7_mirai_scan, columns = chosen_columns)

p7_mirai_syn = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Provision_PT_737E_Security_Camera/mirai_attacks/syn.csv', encoding =␣
 ↪"utf-8", sep = ',' )
df_p7_mirai_syn = p7_mirai_syn.copy(deep=True)
df_p7_mirai_syn = pd.DataFrame(df_p7_mirai_syn, columns = chosen_columns)

p7_mirai_udp = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Provision_PT_737E_Security_Camera/mirai_attacks/udp.csv', encoding =␣
 ↪"utf-8", sep = ',' )
df_p7_mirai_udp = p7_mirai_udp.copy(deep=True)
df_p7_mirai_udp = pd.DataFrame(df_p7_mirai_udp, columns = chosen_columns)

p7_mirai_udpplain = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Provision_PT_737E_Security_Camera/mirai_attacks/udpplain.csv', encoding =␣
 ↪"utf-8", sep = ',' )
df_p7_mirai_udpplain = p7_mirai_udpplain.copy(deep=True)
df_p7_mirai_udpplain = pd.DataFrame(df_p7_mirai_udpplain, columns =␣
 ↪chosen_columns)

# Bashlite

p7_bashlite_combo = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Provision_PT_737E_Security_Camera/gafgyt_attacks/combo.csv', encoding =␣
 ↪"utf-8", sep = ',' )
df_p7_bashlite_combo = p7_bashlite_combo.copy(deep=True)
df_p7_bashlite_combo = pd.DataFrame(df_p7_bashlite_combo, columns =␣
 ↪chosen_columns)

p7_bashlite_junk = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Provision_PT_737E_Security_Camera/gafgyt_attacks/junk.csv', encoding =␣
 ↪"utf-8", sep = ',' )
df_p7_bashlite_junk = p7_bashlite_junk.copy(deep=True)
df_p7_bashlite_junk = pd.DataFrame(df_p7_bashlite_junk, columns =␣
 ↪chosen_columns)

p7_bashlite_scan = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Provision_PT_737E_Security_Camera/gafgyt_attacks/scan.csv', encoding =␣
 ↪"utf-8", sep = ',' )
df_p7_bashlite_scan = p7_bashlite_scan.copy(deep=True)
```

```
df_p7_bashlite_scan = pd.DataFrame(df_p7_bashlite_scan, columns =␣
 ↪chosen_columns)

p7_bashlite_udp = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Provision_PT_737E_Security_Camera/gafgyt_attacks/udp.csv', encoding =␣
 ↪"utf-8", sep = ',' )
df_p7_bashlite_udp = p7_bashlite_udp.copy(deep=True)
df_p7_bashlite_udp = pd.DataFrame(df_p7_bashlite_udp, columns = chosen_columns)

p7_bashlite_tcp = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Provision_PT_737E_Security_Camera/gafgyt_attacks/tcp.csv', encoding =␣
 ↪"utf-8", sep = ',' )
df_p7_bashlite_tcp = p7_bashlite_tcp.copy(deep=True)
df_p7_bashlite_tcp = pd.DataFrame(df_p7_bashlite_tcp, columns = chosen_columns)
```

[12]:

```
df_p7_benign_norm = scaler.fit_transform(df_p7_benign)

df_p7_miraiack_norm = scaler.fit_transform(df_p7_mirai_ack)
df_p7_miraiscan_norm = scaler.fit_transform(df_p7_mirai_scan)
df_p7_miraisyn_norm = scaler.fit_transform(df_p7_mirai_syn)
df_p7_miraiudp_norm = scaler.fit_transform(df_p7_mirai_udp)
df_p7_miraiudpplain_norm = scaler.fit_transform(df_p7_mirai_udpplain)

df_p7_bashlitecombo_norm = scaler.fit_transform(df_p7_bashlite_combo)
df_p7_bashlitejunk_norm = scaler.fit_transform(df_p7_bashlite_junk)
df_p7_bashlitescan_norm = scaler.fit_transform(df_p7_bashlite_scan)
df_p7_bashliteudp_norm = scaler.fit_transform(df_p7_bashlite_udp)
df_p7_bashlitetcp_norm = scaler.fit_transform(df_p7_bashlite_tcp)
```

3.6 2.6 Security Camera

[13]:

```
# Benign traffic

p8_benign = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Provision_PT_838_Security_Camera/benign_traffic.csv', encoding = "utf-8",␣
 ↪sep = ',' )
df_p8_benign = p8_benign.copy(deep=True)
df_p8_benign = pd.DataFrame(df_p8_benign, columns = chosen_columns)

# Mirai

p8_mirai_ack = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Provision_PT_838_Security_Camera/mirai_attacks/ack.csv', encoding = "utf-8",␣
 ↪sep = ',' )
df_p8_mirai_ack = p8_mirai_ack.copy(deep=True)
df_p8_mirai_ack = pd.DataFrame(df_p8_mirai_ack, columns = chosen_columns)
```

```
p8_mirai_scan = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Provision_PT_838_Security_Camera/mirai_attacks/scan.csv', encoding =␣
 ↪"utf-8", sep = ',' )
df_p8_mirai_scan = p8_mirai_scan.copy(deep=True)
df_p8_mirai_scan = pd.DataFrame(df_p8_mirai_scan, columns = chosen_columns)

p8_mirai_syn = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Provision_PT_838_Security_Camera/mirai_attacks/syn.csv', encoding = "utf-8",␣
 ↪sep = ',' )
df_p8_mirai_syn = p8_mirai_syn.copy(deep=True)
df_p8_mirai_syn = pd.DataFrame(df_p8_mirai_syn, columns = chosen_columns)

p8_mirai_udp = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Provision_PT_838_Security_Camera/mirai_attacks/udp.csv', encoding = "utf-8",␣
 ↪sep = ',' )
df_p8_mirai_udp = p8_mirai_udp.copy(deep=True)
df_p8_mirai_udp = pd.DataFrame(df_p8_mirai_udp, columns = chosen_columns)

p8_mirai_udpplain = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Provision_PT_838_Security_Camera/mirai_attacks/udpplain.csv', encoding =␣
 ↪"utf-8", sep = ',' )
df_p8_mirai_udpplain = p8_mirai_udpplain.copy(deep=True)
df_p8_mirai_udpplain = pd.DataFrame(df_p8_mirai_udpplain, columns =␣
 ↪chosen_columns)

# Bashlite

p8_bashlite_combo = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Provision_PT_838_Security_Camera/gafgyt_attacks/combo.csv', encoding =␣
 ↪"utf-8", sep = ',' )
df_p8_bashlite_combo = p8_bashlite_combo.copy(deep=True)
df_p8_bashlite_combo = pd.DataFrame(df_p8_bashlite_combo, columns =␣
 ↪chosen_columns)

p8_bashlite_junk = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Provision_PT_838_Security_Camera/gafgyt_attacks/junk.csv', encoding =␣
 ↪"utf-8", sep = ',' )
df_p8_bashlite_junk = p8_bashlite_junk.copy(deep=True)
df_p8_bashlite_junk = pd.DataFrame(df_p8_bashlite_junk, columns =␣
 ↪chosen_columns)

p8_bashlite_scan = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Provision_PT_838_Security_Camera/gafgyt_attacks/scan.csv', encoding =␣
 ↪"utf-8", sep = ',' )
df_p8_bashlite_scan = p8_bashlite_scan.copy(deep=True)
```

```
df_p8_bashlite_scan = pd.DataFrame(df_p8_bashlite_scan, columns =␣
 ↪chosen_columns)

p8_bashlite_udp = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Provision_PT_838_Security_Camera/gafgyt_attacks/udp.csv', encoding =␣
 ↪"utf-8", sep = ',' )
df_p8_bashlite_udp = p8_bashlite_udp.copy(deep=True)
df_p8_bashlite_udp = pd.DataFrame(df_p8_bashlite_udp, columns = chosen_columns)

p8_bashlite_tcp = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Provision_PT_838_Security_Camera/gafgyt_attacks/tcp.csv', encoding =␣
 ↪"utf-8", sep = ',' )
df_p8_bashlite_tcp = p8_bashlite_tcp.copy(deep=True)
df_p8_bashlite_tcp = pd.DataFrame(df_p8_bashlite_tcp, columns = chosen_columns)
```

[14]:

```
df_p8_benign_norm = scaler.fit_transform(df_p8_benign)

df_p8_miraiack_norm = scaler.fit_transform(df_p8_mirai_ack)
df_p8_miraiscan_norm = scaler.fit_transform(df_p8_mirai_scan)
df_p8_miraisyn_norm = scaler.fit_transform(df_p8_mirai_syn)
df_p8_miraiudp_norm = scaler.fit_transform(df_p8_mirai_udp)
df_p8_miraiudpplain_norm = scaler.fit_transform(df_p8_mirai_udpplain)

df_p8_bashlitecombo_norm = scaler.fit_transform(df_p8_bashlite_combo)
df_p8_bashlitejunk_norm = scaler.fit_transform(df_p8_bashlite_junk)
df_p8_bashlitescan_norm = scaler.fit_transform(df_p8_bashlite_scan)
df_p8_bashliteudp_norm = scaler.fit_transform(df_p8_bashlite_udp)
df_p8_bashlitetcp_norm = scaler.fit_transform(df_p8_bashlite_tcp)
```

3.7 2.7 Security Camera

[15]:

```
# Benign traffic

s2_benign = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪SimpleHome_XCS7_1002_WHT_Security_Camera/benign_traffic.csv', encoding =␣
 ↪"utf-8", sep = ',' )
df_s2_benign = s2_benign.copy(deep=True)
df_s2_benign = pd.DataFrame(df_s2_benign, columns = chosen_columns)

# Mirai

s2_mirai_ack = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪SimpleHome_XCS7_1002_WHT_Security_Camera/mirai_attacks/ack.csv', encoding =␣
 ↪"utf-8", sep = ',' )
df_s2_mirai_ack = s2_mirai_ack.copy(deep=True)
df_s2_mirai_ack = pd.DataFrame(df_s2_mirai_ack, columns = chosen_columns)
```

```
s2_mirai_scan = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪SimpleHome_XCS7_1002_WHT_Security_Camera/mirai_attacks/scan.csv', encoding =␣
 ↪"utf-8", sep = ',' )
df_s2_mirai_scan = s2_mirai_scan.copy(deep=True)
df_s2_mirai_scan = pd.DataFrame(df_s2_mirai_scan, columns = chosen_columns)

s2_mirai_syn = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪SimpleHome_XCS7_1002_WHT_Security_Camera/mirai_attacks/syn.csv', encoding =␣
 ↪"utf-8", sep = ',' )
df_s2_mirai_syn = s2_mirai_syn.copy(deep=True)
df_s2_mirai_syn = pd.DataFrame(df_s2_mirai_syn, columns = chosen_columns)

s2_mirai_udp = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪SimpleHome_XCS7_1002_WHT_Security_Camera/mirai_attacks/udp.csv', encoding =␣
 ↪"utf-8", sep = ',' )
df_s2_mirai_udp = s2_mirai_udp.copy(deep=True)
df_s2_mirai_udp = pd.DataFrame(df_s2_mirai_udp, columns = chosen_columns)

s2_mirai_udpplain = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪SimpleHome_XCS7_1002_WHT_Security_Camera/mirai_attacks/udpplain.csv',␣
 ↪encoding = "utf-8", sep = ',' )
df_s2_mirai_udpplain = s2_mirai_udpplain.copy(deep=True)
df_s2_mirai_udpplain = pd.DataFrame(df_s2_mirai_udpplain, columns =␣
 ↪chosen_columns)

# Bashlite

s2_bashlite_combo = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪SimpleHome_XCS7_1002_WHT_Security_Camera/gafgyt_attacks/combo.csv', encoding␣
 ↪= "utf-8", sep = ',' )
df_s2_bashlite_combo = s2_bashlite_combo.copy(deep=True)
df_s2_bashlite_combo = pd.DataFrame(df_s2_bashlite_combo, columns =␣
 ↪chosen_columns)

s2_bashlite_junk = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪SimpleHome_XCS7_1002_WHT_Security_Camera/gafgyt_attacks/junk.csv', encoding␣
 ↪= "utf-8", sep = ',' )
df_s2_bashlite_junk = s2_bashlite_junk.copy(deep=True)
df_s2_bashlite_junk = pd.DataFrame(df_s2_bashlite_junk, columns =␣
 ↪chosen_columns)

s2_bashlite_scan = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪SimpleHome_XCS7_1002_WHT_Security_Camera/gafgyt_attacks/scan.csv', encoding␣
 ↪= "utf-8", sep = ',' )
df_s2_bashlite_scan = s2_bashlite_scan.copy(deep=True)
```

```
df_s2_bashlite_scan = pd.DataFrame(df_s2_bashlite_scan, columns =␣
 ↪chosen_columns)

s2_bashlite_udp = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪SimpleHome_XCS7_1002_WHT_Security_Camera/gafgyt_attacks/udp.csv', encoding =␣
 ↪"utf-8", sep = ',' )
df_s2_bashlite_udp = s2_bashlite_udp.copy(deep=True)
df_s2_bashlite_udp = pd.DataFrame(df_s2_bashlite_udp, columns = chosen_columns)

s2_bashlite_tcp = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪SimpleHome_XCS7_1002_WHT_Security_Camera/gafgyt_attacks/tcp.csv', encoding =␣
 ↪"utf-8", sep = ',' )
df_s2_bashlite_tcp = s2_bashlite_tcp.copy(deep=True)
df_s2_bashlite_tcp = pd.DataFrame(df_s2_bashlite_tcp, columns = chosen_columns)
```

[16]:

```
df_s2_benign_norm = scaler.fit_transform(df_s2_benign)

df_s2_miraiack_norm = scaler.fit_transform(df_s2_mirai_ack)
df_s2_miraiscan_norm = scaler.fit_transform(df_s2_mirai_scan)
df_s2_miraisyn_norm = scaler.fit_transform(df_s2_mirai_syn)
df_s2_miraiudp_norm = scaler.fit_transform(df_s2_mirai_udp)
df_s2_miraiudpplain_norm = scaler.fit_transform(df_s2_mirai_udpplain)

df_s2_bashlitecombo_norm = scaler.fit_transform(df_s2_bashlite_combo)
df_s2_bashlitejunk_norm = scaler.fit_transform(df_s2_bashlite_junk)
df_s2_bashlitescan_norm = scaler.fit_transform(df_s2_bashlite_scan)
df_s2_bashliteudp_norm = scaler.fit_transform(df_s2_bashlite_udp)
df_s2_bashlitetcp_norm = scaler.fit_transform(df_s2_bashlite_tcp)
```

3.8 2.8 Security Camera

[17]:

```
# Benign traffic

s3_benign = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪SimpleHome_XCS7_1003_WHT_Security_Camera/benign_traffic.csv', encoding =␣
 ↪"utf-8", sep = ',' )
df_s3_benign = s3_benign.copy(deep=True)
df_s3_benign = pd.DataFrame(df_s3_benign, columns = chosen_columns)

# Mirai

s3_mirai_ack = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪SimpleHome_XCS7_1003_WHT_Security_Camera/mirai_attacks/ack.csv', encoding =␣
 ↪"utf-8", sep = ',' )
df_s3_mirai_ack = s3_mirai_ack.copy(deep=True)
df_s3_mirai_ack = pd.DataFrame(df_s3_mirai_ack, columns = chosen_columns)
```

```
s3_mirai_scan = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪SimpleHome_XCS7_1003_WHT_Security_Camera/mirai_attacks/scan.csv', encoding =␣
 ↪"utf-8", sep = ',' )
df_s3_mirai_scan = s3_mirai_scan.copy(deep=True)
df_s3_mirai_scan = pd.DataFrame(df_s3_mirai_scan, columns = chosen_columns)

s3_mirai_syn = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪SimpleHome_XCS7_1003_WHT_Security_Camera/mirai_attacks/syn.csv', encoding =␣
 ↪"utf-8", sep = ',' )
df_s3_mirai_syn = s3_mirai_syn.copy(deep=True)
df_s3_mirai_syn = pd.DataFrame(df_s3_mirai_syn, columns = chosen_columns)

s3_mirai_udp = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪SimpleHome_XCS7_1003_WHT_Security_Camera/mirai_attacks/udp.csv', encoding =␣
 ↪"utf-8", sep = ',' )
df_s3_mirai_udp = s3_mirai_udp.copy(deep=True)
df_s3_mirai_udp = pd.DataFrame(df_s3_mirai_udp, columns = chosen_columns)

s3_mirai_udpplain = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪SimpleHome_XCS7_1003_WHT_Security_Camera/mirai_attacks/udpplain.csv',␣
 ↪encoding = "utf-8", sep = ',' )
df_s3_mirai_udpplain = s3_mirai_udpplain.copy(deep=True)
df_s3_mirai_udpplain = pd.DataFrame(df_s3_mirai_udpplain, columns =␣
 ↪chosen_columns)

# Bashlite

s3_bashlite_combo = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪SimpleHome_XCS7_1003_WHT_Security_Camera/gafgyt_attacks/combo.csv', encoding␣
 ↪= "utf-8", sep = ',' )
df_s3_bashlite_combo = s3_bashlite_combo.copy(deep=True)
df_s3_bashlite_combo = pd.DataFrame(df_s3_bashlite_combo, columns =␣
 ↪chosen_columns)

s3_bashlite_junk = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪SimpleHome_XCS7_1003_WHT_Security_Camera/gafgyt_attacks/junk.csv', encoding␣
 ↪= "utf-8", sep = ',' )
df_s3_bashlite_junk = s3_bashlite_junk.copy(deep=True)
df_s3_bashlite_junk = pd.DataFrame(df_s3_bashlite_junk, columns =␣
 ↪chosen_columns)

s3_bashlite_scan = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪SimpleHome_XCS7_1003_WHT_Security_Camera/gafgyt_attacks/scan.csv', encoding␣
 ↪= "utf-8", sep = ',' )
df_s3_bashlite_scan = s3_bashlite_scan.copy(deep=True)
```

```
df_s3_bashlite_scan = pd.DataFrame(df_s3_bashlite_scan, columns =␣
 ↪chosen_columns)

s3_bashlite_udp = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪SimpleHome_XCS7_1003_WHT_Security_Camera/gafgyt_attacks/udp.csv', encoding =␣
 ↪"utf-8", sep = ',' )
df_s3_bashlite_udp = s3_bashlite_udp.copy(deep=True)
df_s3_bashlite_udp = pd.DataFrame(df_s3_bashlite_udp, columns = chosen_columns)

s3_bashlite_tcp = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪SimpleHome_XCS7_1003_WHT_Security_Camera/gafgyt_attacks/tcp.csv', encoding =␣
 ↪"utf-8", sep = ',' )
df_s3_bashlite_tcp = s3_bashlite_tcp.copy(deep=True)
df_s3_bashlite_tcp = pd.DataFrame(df_s3_bashlite_tcp, columns = chosen_columns)
```

[18]:

```
df_s3_benign_norm = scaler.fit_transform(df_s3_benign)

df_s3_miraiack_norm = scaler.fit_transform(df_s3_mirai_ack)
df_s3_miraiscan_norm = scaler.fit_transform(df_s3_mirai_scan)
df_s3_miraisyn_norm = scaler.fit_transform(df_s3_mirai_syn)
df_s3_miraiudp_norm = scaler.fit_transform(df_s3_mirai_udp)
df_s3_miraiudpplain_norm = scaler.fit_transform(df_s3_mirai_udpplain)

df_s3_bashlitecombo_norm = scaler.fit_transform(df_s3_bashlite_combo)
df_s3_bashlitejunk_norm = scaler.fit_transform(df_s3_bashlite_junk)
df_s3_bashlitescan_norm = scaler.fit_transform(df_s3_bashlite_scan)
df_s3_bashliteudp_norm = scaler.fit_transform(df_s3_bashlite_udp)
df_s3_bashlitetcp_norm = scaler.fit_transform(df_s3_bashlite_tcp)
```

3.9 2.9 Samsung Webcam

[19]:

```
# Benign traffic

sw_benign = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Samsung_SNH_1011_N_Webcam/benign_traffic.csv', encoding = "utf-8", sep = ','␣
 ↪)
df_sw_benign = sw_benign.copy(deep=True)
df_sw_benign = pd.DataFrame(df_sw_benign, columns = chosen_columns)

# Bashlite Only

sw_bashlite_combo = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Samsung_SNH_1011_N_Webcam/gafgyt_attacks/combo.csv', encoding = "utf-8", sep␣
 ↪= ',' )
df_sw_bashlite_combo = sw_bashlite_combo.copy(deep=True)
df_sw_bashlite_combo = pd.DataFrame(df_sw_bashlite_combo, columns =␣
 ↪chosen_columns)

sw_bashlite_junk = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Samsung_SNH_1011_N_Webcam/gafgyt_attacks/junk.csv', encoding = "utf-8", sep␣
 ↪= ',' )
df_sw_bashlite_junk = sw_bashlite_junk.copy(deep=True)
df_sw_bashlite_junk = pd.DataFrame(df_sw_bashlite_junk, columns =␣
 ↪chosen_columns)

sw_bashlite_scan = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Samsung_SNH_1011_N_Webcam/gafgyt_attacks/scan.csv', encoding = "utf-8", sep␣
 ↪= ',' )
df_sw_bashlite_scan = sw_bashlite_scan.copy(deep=True)
df_sw_bashlite_scan = pd.DataFrame(df_sw_bashlite_scan, columns =␣
 ↪chosen_columns)

sw_bashlite_udp = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Samsung_SNH_1011_N_Webcam/gafgyt_attacks/udp.csv', encoding = "utf-8", sep =␣
 ↪',' )
df_sw_bashlite_udp = sw_bashlite_udp.copy(deep=True)
df_sw_bashlite_udp = pd.DataFrame(df_sw_bashlite_udp, columns = chosen_columns)

sw_bashlite_tcp = pd.read_csv('/mnt/extra/2023-1_10Periodo/Poc_II/nbaiot/
 ↪Samsung_SNH_1011_N_Webcam/gafgyt_attacks/tcp.csv', encoding = "utf-8", sep =␣
 ↪',' )
df_sw_bashlite_tcp = sw_bashlite_tcp.copy(deep=True)
df_sw_bashlite_tcp = pd.DataFrame(df_sw_bashlite_tcp, columns = chosen_columns)
```

[20]:

```
df_sw_benign_norm = scaler.fit_transform(df_sw_benign)

df_sw_bashlitecombo_norm = scaler.fit_transform(df_sw_bashlite_combo)
df_sw_bashlitejunk_norm = scaler.fit_transform(df_sw_bashlite_junk)
df_sw_bashlitescan_norm = scaler.fit_transform(df_sw_bashlite_scan)
df_sw_bashliteudp_norm = scaler.fit_transform(df_sw_bashlite_udp)
df_sw_bashlitetcp_norm = scaler.fit_transform(df_sw_bashlite_tcp)
```

4 3. LSTM Autoencoder - Attack Detection

4.1 3.1 Model

[21]:

```
# Train set
len_dd_benign_train = int(0.7 * len(df_dd_benign_norm))
X_train_dd_benign = df_dd_benign_norm[:len_dd_benign_train]

len_et_benign_train = int(0.7 * len(df_et_benign_norm))
```

```
X_train_et_benign = df_et_benign_norm[:len_et_benign_train]

len_ed_benign_train = int(0.7 * len(df_ed_benign_norm))
X_train_ed_benign = df_ed_benign_norm[:len_ed_benign_train]

len_pb_benign_train = int(0.7 * len(df_pb_benign_norm))
X_train_pb_benign = df_pb_benign_norm[:len_pb_benign_train]

len_p7_benign_train = int(0.7 * len(df_p7_benign_norm))
X_train_p7_benign = df_p7_benign_norm[:len_p7_benign_train]

len_p8_benign_train = int(0.7 * len(df_p8_benign_norm))
X_train_p8_benign = df_p8_benign_norm[:len_p8_benign_train]

len_s2_benign_train = int(0.7 * len(df_s2_benign_norm))
X_train_s2_benign = df_s2_benign_norm[:len_s2_benign_train]

len_s3_benign_train = int(0.7 * len(df_s3_benign_norm))
X_train_s3_benign = df_s3_benign_norm[:len_s3_benign_train]

len_sw_benign_train = int(0.7 * len(df_sw_benign_norm))
X_train_sw_benign = df_sw_benign_norm[:len_sw_benign_train]

X_train_AE = np.concatenate([X_train_dd_benign, X_train_et_benign,␣
 ↪X_train_ed_benign, X_train_pb_benign, X_train_p7_benign,
                              X_train_p8_benign, X_train_s2_benign,␣
 ↪X_train_s3_benign])

# Test set - 30% benign and the rest is attack
X_test_dd_benign = df_dd_benign_norm[len_dd_benign_train:]
X_test_et_benign = df_et_benign_norm[len_et_benign_train:]
X_test_ed_benign = df_ed_benign_norm[len_ed_benign_train:]
X_test_pb_benign = df_pb_benign_norm[len_pb_benign_train:]
X_test_p7_benign = df_p7_benign_norm[len_p7_benign_train:]
X_test_p8_benign = df_p8_benign_norm[len_p8_benign_train:]
X_test_s2_benign = df_s2_benign_norm[len_s2_benign_train:]
X_test_s3_benign = df_s3_benign_norm[len_s3_benign_train:]
X_test_sw_benign = df_sw_benign_norm[len_sw_benign_train:]

X_test_benign = np.concatenate([X_test_dd_benign, X_test_et_benign,␣
 ↪X_test_ed_benign, X_test_pb_benign, X_test_p7_benign,
                                X_test_p8_benign, X_test_s2_benign,␣
 ↪X_test_s3_benign, X_test_sw_benign])

# 30% benign + attacks
X_test_AE = np.concatenate([X_test_benign,
                             df_dd_miraiack_norm, df_dd_miraiscan_norm,␣
 ↪df_dd_miraisyn_norm, df_dd_miraiudp_norm, df_dd_miraiudpplain_norm,
                             df_dd_bashlitecombo_norm, df_dd_bashlitejunk_norm,␣
 ↪df_dd_bashlitescan_norm, df_dd_bashliteudp_norm, df_dd_bashlitetcp_norm,
                             df_et_miraiack_norm, df_et_miraiscan_norm,␣
 ↪df_et_miraisyn_norm, df_et_miraiudp_norm, df_et_miraiudpplain_norm,
                             df_et_bashlitecombo_norm, df_et_bashlitejunk_norm,␣
 ↪df_et_bashlitescan_norm, df_et_bashliteudp_norm, df_et_bashlitetcp_norm,
                             df_ed_bashlitecombo_norm, df_ed_bashlitejunk_norm,␣
 ↪df_ed_bashlitescan_norm, df_ed_bashliteudp_norm, df_ed_bashlitetcp_norm,
                             df_pb_miraiack_norm, df_pb_miraiscan_norm,␣
 ↪df_pb_miraisyn_norm, df_pb_miraiudp_norm, df_pb_miraiudpplain_norm,
                             df_pb_bashlitecombo_norm, df_pb_bashlitejunk_norm,␣
 ↪df_pb_bashlitescan_norm, df_pb_bashliteudp_norm, df_pb_bashlitetcp_norm,
                             df_p7_miraiack_norm, df_p7_miraiscan_norm,␣
 ↪df_p7_miraisyn_norm, df_p7_miraiudp_norm, df_p7_miraiudpplain_norm,
                             df_p7_bashlitecombo_norm, df_p7_bashlitejunk_norm,␣
 ↪df_p7_bashlitescan_norm, df_p7_bashliteudp_norm, df_p7_bashlitetcp_norm,
                             df_p8_miraiack_norm, df_p8_miraiscan_norm,␣
 ↪df_p8_miraisyn_norm, df_p8_miraiudp_norm, df_p8_miraiudpplain_norm,
                             df_p8_bashlitecombo_norm, df_p8_bashlitejunk_norm,␣
 ↪df_p8_bashlitescan_norm, df_p8_bashliteudp_norm, df_p8_bashlitetcp_norm,
                             df_s2_miraiack_norm, df_s2_miraiscan_norm,␣
 ↪df_s2_miraisyn_norm, df_s2_miraiudp_norm, df_s2_miraiudpplain_norm,
                             df_s2_bashlitecombo_norm, df_s2_bashlitejunk_norm,␣
 ↪df_s2_bashlitescan_norm, df_s2_bashliteudp_norm, df_s2_bashlitetcp_norm,
                             df_s3_miraiack_norm, df_s3_miraiscan_norm,␣
 ↪df_s3_miraisyn_norm, df_s3_miraiudp_norm, df_s3_miraiudpplain_norm,
                             df_s3_bashlitecombo_norm, df_s3_bashlitejunk_norm,␣
 ↪df_s3_bashlitescan_norm, df_s3_bashliteudp_norm, df_s3_bashlitetcp_norm,
                             df_sw_bashlitecombo_norm, df_sw_bashlitejunk_norm,␣
 ↪df_sw_bashlitescan_norm, df_sw_bashliteudp_norm, df_sw_bashlitetcp_norm])

X_train_label = np.zeros(len(X_train_AE))

Y_test_AE = np.ones(len(X_test_AE))
Y_test_AE[:len(X_test_benign)] = 0
```

```
[22]: 6506674 + 166784
```

```
[22]: 6673458
```

```
[23]: 166784/6673458
```

```
[23]: 0.024992140506466063
```

[24]:
```
X_train_AE.shape, X_test_AE.shape, Y_test_AE.shape
```

[24]:
```
((352643, 23), (6673458, 23), (6673458,))
```

[25]:
```
# reshape inputs for LSTM [samples, timesteps, features]
X_train = X_train_AE.reshape(X_train_AE.shape[0], 1, X_train_AE.shape[1])
print(f'Training data shape: {X_train.shape}')

X_test = X_test_AE.reshape(X_test_AE.shape[0], 1, X_test_AE.shape[1])
print(f'Test data shape: {X_test.shape}')
```

```
Training data shape: (352643, 1, 23)
Test data shape: (6673458, 1, 23)
```

[26]:
```
# define the autoencoder network model
def autoencoder_model(X):
    inputs = Input(shape=(X.shape[1], X.shape[2]))
    L1 = LSTM(16, activation='relu', return_sequences=True,␣
 ↪kernel_regularizer=regularizers.l2(0.00))(inputs)
    L2 = LSTM(4, activation='relu', return_sequences=False)(L1)
    L3 = RepeatVector(X.shape[1])(L2)
    L4 = LSTM(4, activation='relu', return_sequences=True)(L3)
    L5 = LSTM(16, activation='relu', return_sequences=True)(L4)

    output = TimeDistributed(Dense(X.shape[2]))(L5)
    model = Model(inputs=inputs, outputs=output)

    return model

# KL Loss function
def vae_loss(x, x_decoded_mean):
    # Compute the average MSE error, then scale it up (sum on all axes)
    reconstruction_loss = K.sum(K.square(x - x_decoded_mean))

    # Compute the KL loss
    kl_loss = - 0.5 * K.sum(1 + z_var - K.square(z_mean) - K.square(K.
 ↪exp(z_var)), axis=-1)

    # Return the average loss over all
    total_loss = K.mean(reconstruction_loss + kl_loss) # Total_loss =␣
 ↪reconstruction_loss + kl_loss

    return total_loss

# (1) Reconstruction Loss - Forces the encoder to generate latent features that␣
 ↪minimize the reconstruction error, or else is penalized
```

```python
# (2) KL Loss - Forces the distribution generated by the encoder to be similar to the prior probability of the input vector, pushing latent feature space to normality

def saveHist(path, history):
    with codecs.open(path, 'w', encoding='utf-8') as f:
        json.dump(history, f, separators=(',', ':'), sort_keys=True, indent=4)

def loadHist(path):
    n = {} # set history to empty
    if os.path.exists(path): # reload history if it exists
        with codecs.open(path, 'r', encoding='utf-8') as f:
            n = json.loads(f.read())
    return n

def appendHist(h1, h2):
    if h1 == {}:
        return h2
    else:
        dest = {}
        for key, value in h1.items():
            dest[key] = value + h2[key]
        return dest

model_loaded = False
```

[27]:

```python
learning_rate = 0.001           # learning rate for optimizer

# maybe the random results of metrics is because Adam opt - Use SGD instead
# opt = tf.keras.optimizers.experimental.SGD(lr = learning_rate, momentum=0.9)

opt = tf.keras.optimizers.Adam(learning_rate = learning_rate)

# create the autoencoder model
model = autoencoder_model(X_train)
model.compile(optimizer=opt, loss='mae', metrics=['accuracy'])

model.summary()
```

```
2023-06-22 09:45:34.562228: E
tensorflow/compiler/xla/stream_executor/cuda/cuda_driver.cc:266] failed call to
cuInit: CUDA_ERROR_NO_DEVICE: no CUDA-capable device is detected
2023-06-22 09:45:34.562401: I
tensorflow/compiler/xla/stream_executor/cuda/cuda_diagnostics.cc:168] retrieving
CUDA diagnostic information for host: pop-os
2023-06-22 09:45:34.562410: I
tensorflow/compiler/xla/stream_executor/cuda/cuda_diagnostics.cc:175] hostname:
```

```
pop-os
2023-06-22 09:45:34.562556: I
tensorflow/compiler/xla/stream_executor/cuda/cuda_diagnostics.cc:199] libcuda
reported version is: 525.116.4
2023-06-22 09:45:34.562593: I
tensorflow/compiler/xla/stream_executor/cuda/cuda_diagnostics.cc:203] kernel
reported version is: 525.116.4
2023-06-22 09:45:34.562599: I
tensorflow/compiler/xla/stream_executor/cuda/cuda_diagnostics.cc:309] kernel
version seems to match DSO: 525.116.4
```

```
Model: "model"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 input_1 (InputLayer)        [(None, 1, 23)]           0

 lstm (LSTM)                 (None, 1, 16)             2560

 lstm_1 (LSTM)               (None, 4)                 336

 repeat_vector (RepeatVector  (None, 1, 4)             0
 )

 lstm_2 (LSTM)               (None, 1, 4)              144

 lstm_3 (LSTM)               (None, 1, 16)             1344

 time_distributed (TimeDistr  (None, 1, 23)            391
 ibuted)

=================================================================
Total params: 4,775
Trainable params: 4,775
Non-trainable params: 0
_________________________________________________________________
```

4.2 3.2 Train

[28]:

```
# fit the model to the data
# nb_epochs = 100
# batch_size = 32

# train_start = time.time()
# history = model.fit(X_train, X_train,
#                     epochs = nb_epochs,
#                     batch_size = batch_size,
#                     validation_split = 0.10,
#                     shuffle = False).history
# train_end = time.time()
# train_time = train_end - train_start

# print(f"Fit time: {train_time:.2f}s")
```

[29]:

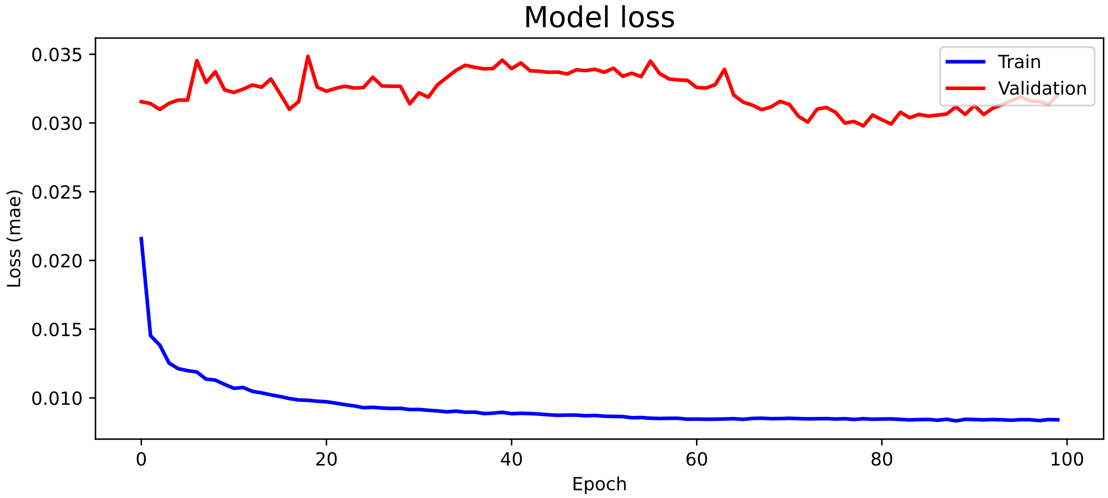
```
# history_filename = 'history_26-05.json'

# model.save("lstm_model_26-05")
# saveHist(history_filename, history)
```

[30]:

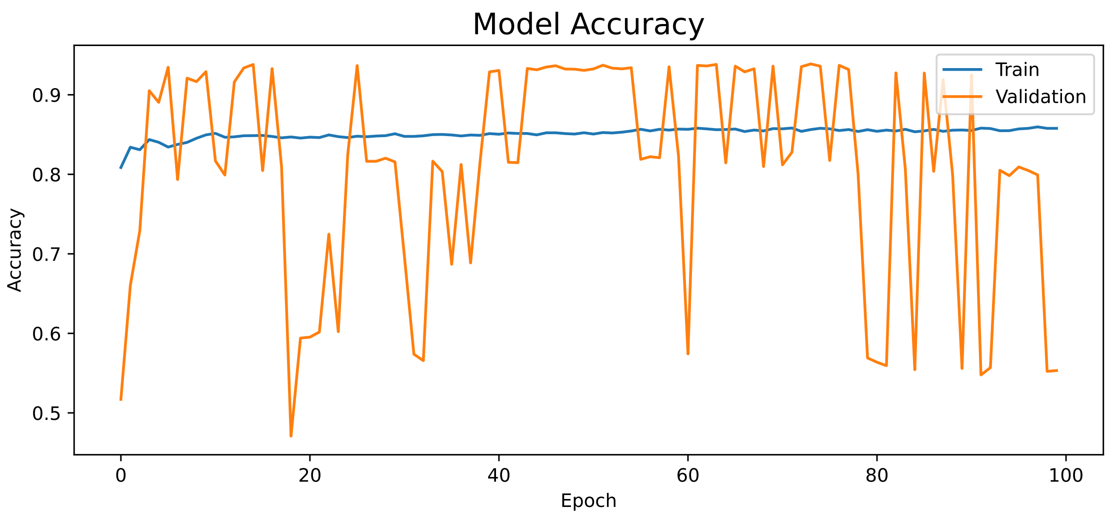
```
# It can be used to reconstruct the model identically.
lstm_model = keras.models.load_model("lstm_model_26-05")
history = loadHist('history_26-05.json')

model_loaded = True

lstm_model.summary()

# result = lstm_model.score(X_test, Y_test)
# print(result)
```

```
Model: "model"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 input_1 (InputLayer)        [(None, 1, 23)]           0

 lstm (LSTM)                 (None, 1, 16)             2560

 lstm_1 (LSTM)               (None, 4)                 336

 repeat_vector (RepeatVector  (None, 1, 4)             0
 )

 lstm_2 (LSTM)               (None, 1, 4)              144

 lstm_3 (LSTM)               (None, 1, 16)             1344

 time_distributed (TimeDistr  (None, 1, 23)            391
 ibuted)

=================================================================
Total params: 4,775
Trainable params: 4,775
Non-trainable params: 0
_________________________________________________________________
```

[31]:
```
# sns.set(color_codes=True)

# plot the training and validation losses
fig, ax = plt.subplots(figsize=(10, 4), dpi=80)

ax.plot(history['loss'], 'b', label='Train', linewidth=2)
ax.plot(history['val_loss'], 'r', label='Validation', linewidth=2)
ax.set_title('Model loss', fontsize=16)
#ax.set_ylim([0, 0.04])
ax.set_ylabel('Loss (mae)')
ax.set_xlabel('Epoch')
ax.legend(loc='upper right')

plt.show()
```



[32]:
```
# plot the training and validation accuracys
fig, ax = plt.subplots(figsize=(10, 4), dpi=80)
ax.plot(history['accuracy'], label='Train')
ax.plot(history['val_accuracy'], label='Validation')
ax.set_title('Model Accuracy', fontsize=16)
ax.set_ylabel('Accuracy')
#ax.set_ylim([0.45, 1.05])
ax.set_xlabel('Epoch')
ax.legend(loc='upper right')

plt.show()
```



Predict on X_train

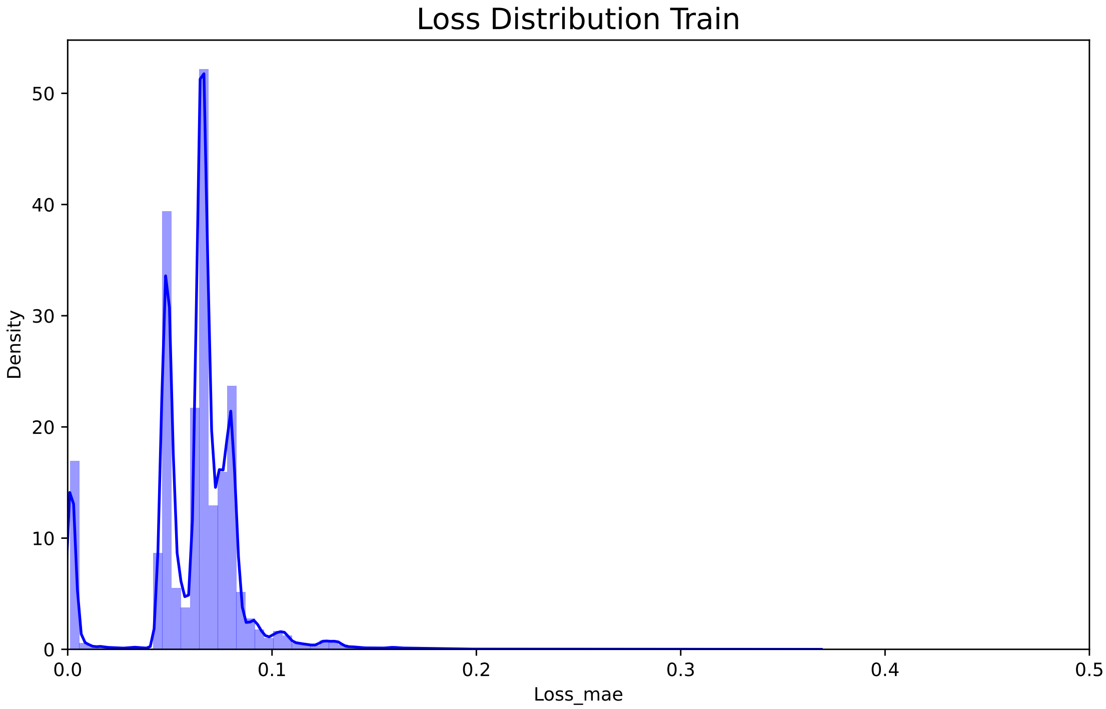
[33]:
```
train_start = time.time()

if model_loaded:
    X_pred_train = lstm_model.predict(X_train)
else:
    X_pred_train = model.predict(X_train)

train_end = time.time()
train_time = train_end - train_start
print(f"Training time: {train_time:.2f}s")
```

```
11021/11021 [==============================] - 16s 1ms/step
Training time: 20.28s
```

[34]:
```
X_pred_train = X_pred_train.reshape(X_pred_train.shape[0], X_pred_train.
  ↪shape[2])
X_pred_train = pd.DataFrame(X_pred_train, columns=df_sw_benign.columns)
X_pred_train.index = pd.RangeIndex.from_range(range(0, len(X_train_AE)))

scored_train = pd.DataFrame(index=pd.RangeIndex.from_range(range(0,␣
  ↪len(X_train_AE))))
Xtrain = X_train.reshape(X_train.shape[0], X_train.shape[2])
```

[35]:
```
scored_train['Loss_mae'] = np.mean(np.abs(X_pred_train - Xtrain), axis = 1)
plt.figure(figsize=(10, 6), dpi=80)
plt.title("Loss Distribution Train", fontsize=16)

sns.distplot(scored_train['Loss_mae'], bins = 80, kde=True, color='blue');
```

```
plt.xlim([0.0, .5]);
```



[36]:
```
# threshold = 0.09 # threshold from loss_mae plot above   ***
threshold = np.quantile(scored_train['Loss_mae'], 0.95)
print(threshold)

scored_train['Threshold'] = threshold
scored_train['Anomaly'] = scored_train['Loss_mae'] > scored_train['Threshold']
```

```
0.09107424507651884
```

[37]:
```
scored_train['Anomaly'].value_counts()
```

[37]:
```
Anomaly
False    335010
True      17633
Name: count, dtype: int64
```

[38]:
```
target_names = ['Benign', 'Attack']

print(f"Training time: {train_time / 60:.2f} min")
print(classification_report(X_train_label, scored_train['Anomaly'],␣
 ↪target_names=target_names, digits = 5))
```

```
Training time: 0.34 min
              precision    recall  f1-score   support

      Benign    1.00000   0.95000   0.97436    352643
      Attack    0.00000   0.00000   0.00000         0

    accuracy                        0.95000    352643
   macro avg    0.50000   0.47500   0.48718    352643
weighted avg    1.00000   0.95000   0.97436    352643
```

[39]:

```
# Percentage of attacks predicted in training data
print(f"Attacks Predicted: {np.count_nonzero(scored_train['Anomaly']==1) /␣
 ↪len(scored_train['Anomaly']):.6f}")
```

```
Attacks Predicted: 0.050002
```

Predicao somente com dados Benignos (30%) == Cenário Normal

[40]:

```
Xtest_benign = X_test_benign.reshape(X_test_benign.shape[0], 1, X_test_benign.
 ↪shape[1])

test_start = time.time()

if model_loaded:
    X_pred_LSTM_ = lstm_model.predict(Xtest_benign)
else:
    X_pred_LSTM_ = model.predict(Xtest_benign)

test_end = time.time()
test_time = test_end - test_start
print(f"Testing time: {test_time:.2f}s\n")
```

```
5212/5212 [==============================] - 8s 2ms/step
Testing time: 10.64s
```

[41]:

```
X_pred_test_benign = X_pred_LSTM_.reshape(X_pred_LSTM_.shape[0], X_pred_LSTM_.
 ↪shape[2])
X_pred_test_benign = pd.DataFrame(X_pred_test_benign, columns=df_sw_benign.
 ↪columns)
X_pred_test_benign.index = pd.RangeIndex.from_range(range(0,␣
 ↪len(X_test_benign))) # cria um objeto RangeIndex do tam de X_test_AE

scored_test_benign = pd.DataFrame(index=pd.RangeIndex.from_range(range(0,␣
 ↪len(X_test_benign))))
```

```
Xtest_benign = Xtest_benign.reshape(Xtest_benign.shape[0], Xtest_benign.
 ↪shape[2])
```

[42]:

```
# calculate the loss on the test set
scored_test_benign['Loss_mae'] = np.mean(np.abs(X_pred_test_benign -␣
 ↪Xtest_benign), axis = 1)     # error vector in testing data
scored_test_benign['Threshold'] = threshold
scored_test_benign['Anomaly'] = scored_test_benign['Loss_mae'] >␣
 ↪scored_test_benign['Threshold'] # if > then == attack
```

[43]:

```
scored_test_benign.head(10)
```

[43]:

```
   Loss_mae  Threshold  Anomaly
0  0.069983   0.091074    False
1  0.113978   0.091074     True
2  0.182516   0.091074     True
3  0.078173   0.091074    False
4  0.081123   0.091074    False
5  0.079617   0.091074    False
6  0.079120   0.091074    False
7  0.080085   0.091074    False
8  0.082644   0.091074    False
9  0.079993   0.091074    False
```

[44]:

```
# Percentage of attacks predicted
print(f"Attacks Predicted (only benign): {np.
 ↪count_nonzero(scored_test_benign['Anomaly']==1) /␣
 ↪len(scored_test_benign['Anomaly']):.6f}")
```

```
Attacks Predicted (only benign): 0.040346
```

Majority Vote

[45]:

```
# Assuming you have the reconstruction errors stored in a
# list or numpy array called 'reconstruction_errors' and 'threshold'
# represents the threshold value for determining anomalies.

window_size = 96  # Size of the Sliding Window

def detect_anomalies_with_sliding_window(reconstruction_errors, threshold):
    num_samples = len(reconstruction_errors)
    anomaly_labels = np.zeros(num_samples)  # Initialize the anomaly labels

    for i in range(0, num_samples, window_size):
        # print(i)
        window_errors = reconstruction_errors[i:i+window_size]
        # print(window_errors)
        # If the majority of errors in the window exceed the threshold, label␣
 ↪the window as anomalous
        if sum(i > threshold for i in window_errors) > (len(window_errors) / 2):
            anomaly_labels[i:i+window_size] = 1

    return anomaly_labels

anomaly_labels =␣
 ↪detect_anomalies_with_sliding_window(scored_test_benign['Anomaly'],␣
 ↪threshold)
# print(f'\n\nAnomaly: {anomaly_labels}')

print(np.unique(scored_test_benign['Anomaly'], return_counts=True))
np.unique(anomaly_labels, return_counts=True)
```

```
(array([False,  True]), array([160055,   6729]))
```

[45]:
```
(array([0., 1.]), array([165824,    960]))
```

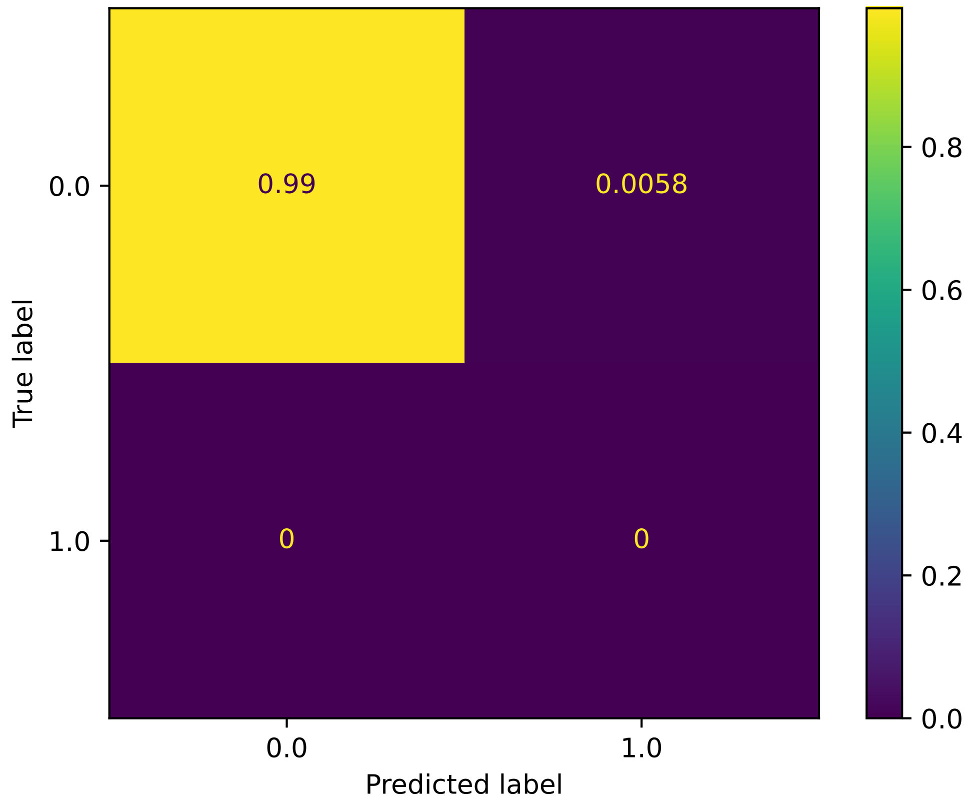
Metrics with Majority Vote

[47]:
```
print(f"Testing time: {test_time / 60:.2f} min")
print(classification_report(np.zeros(len(anomaly_labels)), anomaly_labels,␣
 ↪target_names=target_names, digits = 5))
```

```
Testing time: 0.18 min
              precision    recall  f1-score   support

      Benign    1.00000   0.99424   0.99711    166784
      Attack    0.00000   0.00000   0.00000         0

    accuracy                        0.99424    166784
   macro avg    0.50000   0.49712   0.49856    166784
weighted avg    1.00000   0.99424   0.99711    166784
```

[48]:
```
print(confusion_matrix(np.zeros(len(anomaly_labels)), anomaly_labels))
ConfusionMatrixDisplay.from_predictions(np.zeros(len(anomaly_labels)),␣
 ↪anomaly_labels, normalize='all')

plt.show()
```

```
[[165824    960]
 [     0      0]]
```



```
[ ]: print(f"Attacks Predicted using Sliding Window: {np.
      ↪count_nonzero(anomaly_labels==1) / len(anomaly_labels):.6f}")
```

```
Attacks Predicted using Sliding Window: 0.005756
```

4.3 3.3 Test

Predicao com dados Benignos (30%) + Ataques (70%) == Cenário sob Ataque

```
[49]: # Predict on test data
test_start = time.time()

if model_loaded:
    X_pred_test = lstm_model.predict(X_test)
else:
    X_pred_test = model.predict(X_test)

test_end = time.time()
test_time = test_end - test_start
print(f"Testing Time: {test_time:.2f}s")
```

```
    27/208546 […] - ETA: 6:57
```

```
2023-06-22 09:58:56.337525: W tensorflow/tsl/framework/cpu_allocator_impl.cc:83]
Allocation of 613958136 exceeds 10% of free system memory.
```

```
208546/208546 [==============================] - 305s 1ms/step
```

```
2023-06-22 10:05:35.284799: W tensorflow/tsl/framework/cpu_allocator_impl.cc:83]
Allocation of 613958136 exceeds 10% of free system memory.
```

```
Testing Time: 400.14s
```

[50]:
```
X_pred_test = X_pred_test.reshape(X_pred_test.shape[0], X_pred_test.shape[2])
X_pred_test = pd.DataFrame(X_pred_test, columns=df_sw_benign.columns)
X_pred_test.index = pd.RangeIndex.from_range(range(0, len(X_test_AE))) # cria␣
 ↪um objeto RangeIndex do tam de X_test_AE

scored_test = pd.DataFrame(index=pd.RangeIndex.from_range(range(0,␣
 ↪len(X_test_AE))))
Xtest = X_test.reshape(X_test.shape[0], X_test.shape[2])
```

[51]:
```
# calculate the loss on the test set
scored_test['Loss_mae'] = np.mean(np.abs(X_pred_test - Xtest), axis = 1)    #␣
 ↪error vector in testing data
scored_test['Threshold'] = threshold
scored_test['Anomaly'] = scored_test['Loss_mae'] > scored_test['Threshold'] #␣
 ↪if > then == attack

scored_test.head(10)
```

[51]:
```
   Loss_mae  Threshold  Anomaly
0  0.069983   0.091074    False
1  0.113978   0.091074     True
2  0.182516   0.091074     True
3  0.078173   0.091074    False
4  0.081123   0.091074    False
5  0.079617   0.091074    False
6  0.079120   0.091074    False
7  0.080085   0.091074    False
8  0.082644   0.091074    False
9  0.079993   0.091074    False
```

4.3.1 3.4 Metrics without Sliding Window

[52]:
```
# Quantidade real de dados benignos e de ataque no teste
print(np.unique(Y_test_AE, return_counts=True))

scored_test['Anomaly'].value_counts()
```

```
(array([0., 1.]), array([ 166784, 6506674]))
```

[52]:

```
Anomaly
True     6506112
False     167346
Name: count, dtype: int64
```

[53]:

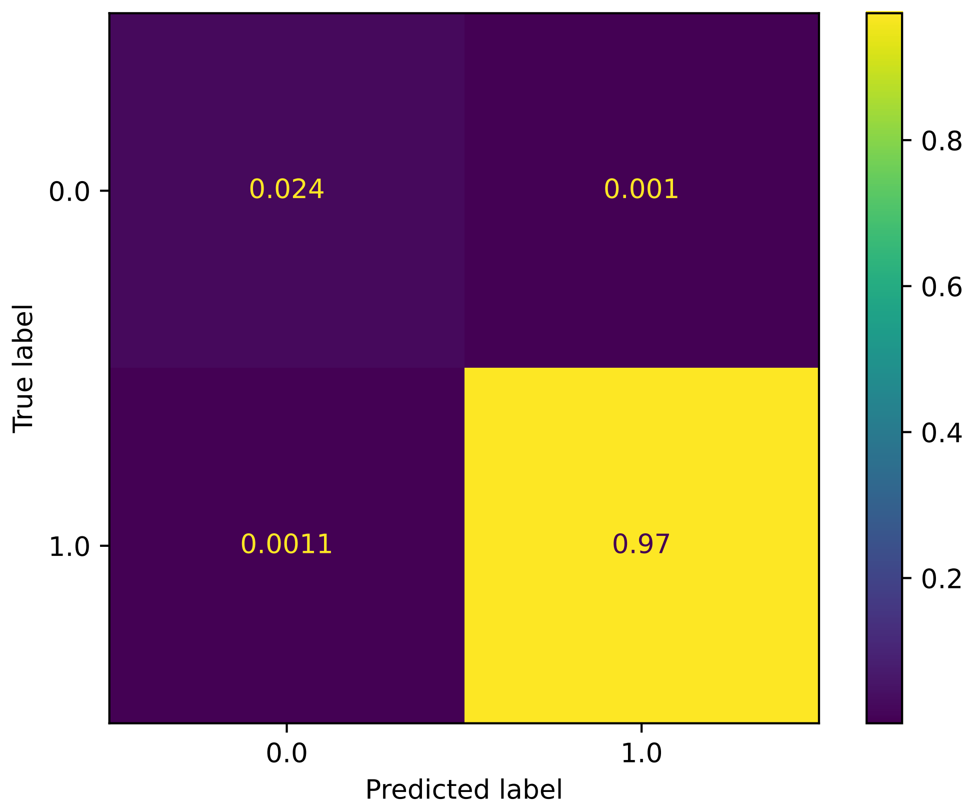
```
print(f"Testing time: {test_time / 60:.2f} min")
print(classification_report(Y_test_AE, scored_test['Anomaly'],␣
 ↪target_names=target_names, digits = 5))
```

```
Testing time: 6.67 min
              precision    recall  f1-score   support

      Benign    0.95643   0.95965   0.95804    166784
      Attack    0.99897   0.99888   0.99892   6506674

    accuracy                        0.99790   6673458
   macro avg    0.97770   0.97927   0.97848   6673458
weighted avg    0.99790   0.99790   0.99790   6673458
```

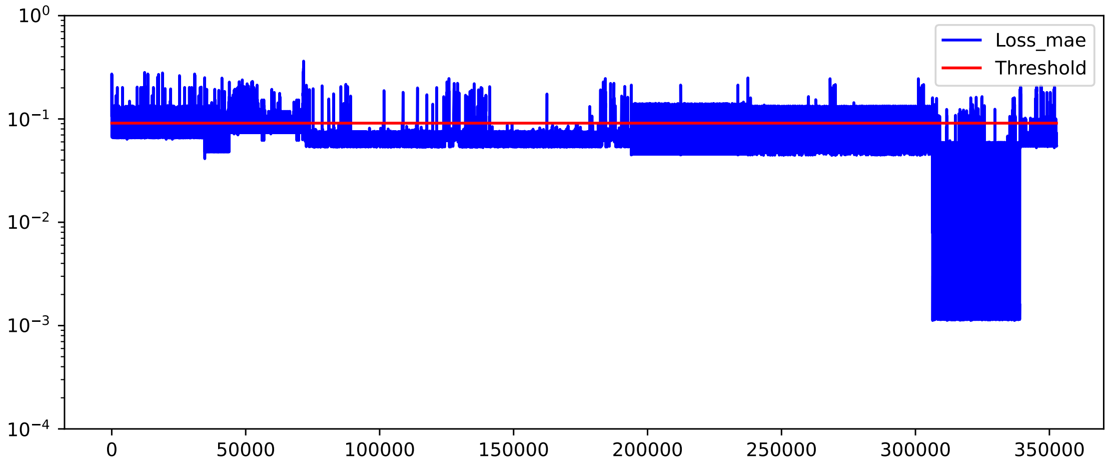
[54]:

```
print(confusion_matrix(Y_test_AE, scored_test['Anomaly']))
ConfusionMatrixDisplay.from_predictions(Y_test_AE, scored_test['Anomaly'],␣
 ↪normalize='all')

plt.show()
```

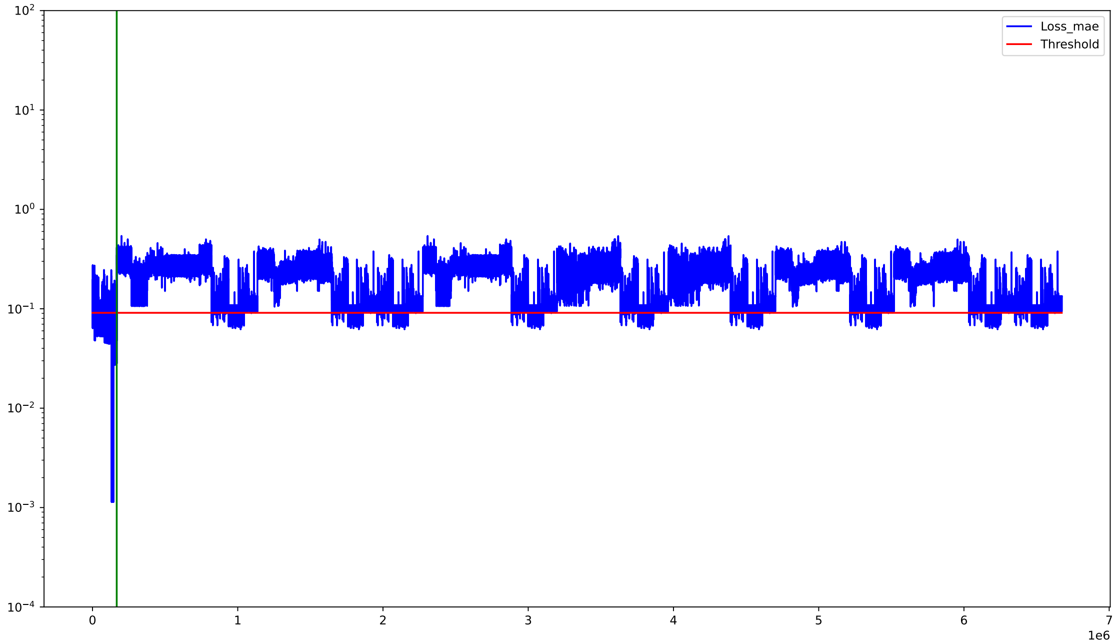
```
[[ 160055    6729]
 [   7291 6499383]]
```



```
[55]: scored_train.plot(logy=True, figsize=(10,4), ylim=[1e-4, 1e0], color=['blue',␣
        ↪'red'], kind='line')
      plt.show()
```



[56]:
```
scored_test.plot(logy=True, figsize=(16,9), ylim=[1e-4, 1e2], color=['blue',␣
 ↪'red'], kind='line')
plt.axvline(len(X_test_benign), color='green')

plt.show()
```



4.3.2 Majority Vote

[57]:
```
threshold, window_size
```

[57]:
```
(0.09107424507651884, 96)
```

[ ]:
```
'''
(array([0., 1.]), array([ 166784, 6506674]))
'''
```

[58]:
```
anomaly_labels_ = detect_anomalies_with_sliding_window(scored_test['Anomaly'],␣
 ↪threshold)

print(np.unique(scored_test['Anomaly'], return_counts=True))
np.unique(anomaly_labels_, return_counts=True)
```

```
(array([False,  True]), array([ 167346, 6506112]))
```

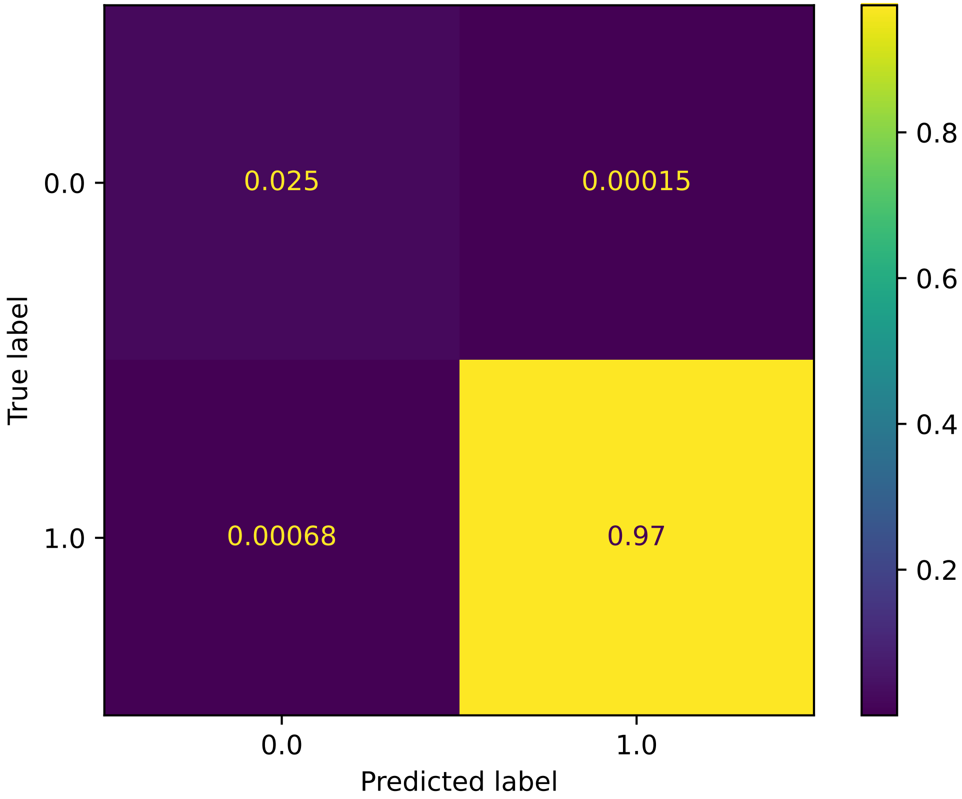
[58]:
```
(array([0., 1.]), array([ 170304, 6503154]))
```

```
[61]: print(classification_report(Y_test_AE, anomaly_labels_,␣
       ↪target_names=target_names, digits = 5))
```

```
              precision    recall  f1-score   support

      Benign    0.97351   0.99405   0.98367    166784
      Attack    0.99985   0.99931   0.99958   6506674

    accuracy                        0.99918   6673458
   macro avg    0.98668   0.99668   0.99162   6673458
weighted avg    0.99919   0.99918   0.99918   6673458
```

```
[62]: print(confusion_matrix(Y_test_AE, anomaly_labels_))
      ConfusionMatrixDisplay.from_predictions(Y_test_AE, anomaly_labels_,␣
       ↪normalize='all')

      plt.show()
```

```
[[ 165792     992]
 [   4512 6502162]]
```



[ ]:

```
```