IoT_Botnet_Detection-VAE

May 17, 2023

1 Table of Contents

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

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 tensorflow as tf
```

```
tf.random.set_seed(2023)
tf.compat.v1.disable_eager_execution()

from datetime import datetime
import matplotlib.pyplot as plt
import seaborn as sns
import pandas as pd
import math
import time
import sys

from tensorflow.keras.models import Model
from tensorflow.keras.layers import Lambda, Input, Dense
from tensorflow.keras.losses import mse
from tensorflow.keras import optimizers
from tensorflow.keras import backend as K

from sklearn.pipeline import Pipeline
from sklearn.preprocessing import MinMaxScaler
from sklearn.metrics import classification_report, mean_squared_error,␣
 ↪confusion_matrix, accuracy_score, f1_score, precision_score, recall_score
from sklearn.metrics import ConfusionMatrixDisplay

%matplotlib inline

import json, codecs
```

```
2023-05-17 11:03:34.513332: I tensorflow/tsl/cuda/cudart_stub.cc:28] Could not
find cuda drivers on your machine, GPU will not be used.
2023-05-17 11:03:34.573252: I tensorflow/tsl/cuda/cudart_stub.cc:28] Could not
find cuda drivers on your machine, GPU will not be used.
2023-05-17 11:03:34.574121: 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.
2023-05-17 11:03:35.675078: 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. Variational 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_VAE = 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_VAE = 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])

Y_test_VAE = np.ones(len(X_test_VAE))
Y_test_VAE[:len(X_test_benign)] = 0
```

[22]:
```
X_train_VAE.shape, X_test_VAE.shape, Y_test_VAE.shape
```

[22]:
```
((352643, 23), (6673458, 23), (6673458,))
```

[23]:
```
# 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
# (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
```

[24]:
```
# Parameters
original_dim = X_train_VAE.shape[1]
input_shape = (original_dim,)
intermediate_dim = int(original_dim / 2)
latent_dim = int(original_dim / 3)

epochs = 100
learning_rate = 0.0001          # learning rate
batch_size = 40
anomaly_threshold = 0.05
number_features = 23

history_filename = 'history.json'
```

[25]:
```
# Encoder Model

# The encoder learns a function that takes an input array of size n and can␣
 ↪generate two vectors that represents the
# parameters (mean and variance) of a distribution from which the latent vector␣
 ↪is sampled.

# encoder(input_vector[]) => latent_v_mu[], latent_v_lvar[]
# So that - latent_v[0] ~  N(latent_v_mu[0], latent_v_lvar[0])
# and latent_v[1] ~  N(latent_v_mu[1], latent_v_lvar[1])

def vae_encoder(input_shape, intermediate_dim, latent_dim, sample):
    inputs = Input(shape = input_shape, name = 'encoder_input')
    x = Dense(intermediate_dim, activation = 'relu')(inputs)

    z_mean = Dense(latent_dim, name = 'z_mean')(x)
    z_var = Dense(latent_dim, name = 'z_var')(x)
```

```
    z = Lambda(sample, output_shape = (latent_dim,), name = 'z')([z_mean,␣
 ↪z_var])

    encoder = Model(inputs, z, name = 'encoder')
    return inputs, encoder, z_var, z_mean

# Reparameterization trick
def sample(args):
    z_mean, z_var = args
    batch = K.shape(z_mean)[0]
    dim = K.int_shape(z_mean)[1]
    epsilon = K.random_normal(shape = (batch, dim))

    return z_mean + K.exp(0.5 * z_var) * epsilon

# Sample the normally distributed z - mean + sigma * epsilon. The epsilon␣
 ↪ensures the continuity of latent space and helps
# the network to keep correcting its parameters through backpropagation

# Decoder model
def vae_decoder(intermediate_dim, latent_dim, original_dim):
    latent_inputs = Input(shape = (latent_dim,), name = 'z_sampling')
    x = Dense(intermediate_dim, activation = 'relu')(latent_inputs)
    outputs = Dense(original_dim, activation = 'sigmoid')(x)

    # Instantiate the decoder model
    decoder = Model(latent_inputs, outputs, name = 'decoder')

    return decoder

# Transforms the latent feature space composed by distributions of mean and␣
 ↪variance back to the original input vector

# Get error term
def get_error_term(v1, v2, _rmse = True):
    if _rmse:
        return np.sqrt(np.mean((v1 - v2) ** 2, axis = 1))

    return np.mean(abs(v1 - v2), axis = 1)

# Calculates the error between the original vector and the predicted one

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
```

[26]:
```
# Encoder
inputs, encoder, z_var, z_mean = vae_encoder(
    input_shape,
    intermediate_dim,
    latent_dim,
    sample)

encoder.summary()
```

```
Model: "encoder"
__________________________________________________________________________________
__________________
 Layer (type)                   Output Shape         Param #     Connected to
==================================================================================
==================
 encoder_input (InputLayer)     [(None, 23)]         0           []

 dense (Dense)                  (None, 11)           264
['encoder_input[0][0]']

 z_mean (Dense)                 (None, 7)            84          ['dense[0][0]']

 z_var (Dense)                  (None, 7)            84          ['dense[0][0]']

 z (Lambda)                     (None, 7)            0
['z_mean[0][0]',
                                                                  'z_var[0][0]']

==================================================================================
==================
Total params: 432
Trainable params: 432
```

```
Non-trainable params: 0
_________________________________________________________________________________
_________________
```

[27]:
```
# Decoder
decoder = vae_decoder(
    intermediate_dim,
    latent_dim,
    original_dim)

decoder.summary()
```

```
Model: "decoder"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 z_sampling (InputLayer)     [(None, 7)]               0

 dense_1 (Dense)             (None, 11)                88

 dense_2 (Dense)             (None, 23)                276

=================================================================
Total params: 364
Trainable params: 364
Non-trainable params: 0
_________________________________________________________________
```

[28]:
```
# VAE model
outputs = decoder(encoder(inputs))

opt = tf.keras.optimizers.legacy.Adam(learning_rate = learning_rate, clipvalue␣
 ↪= 0.5)

vae_model = Model(inputs, outputs, name = 'vae_mlp')
vae_model.compile(optimizer = opt, loss = vae_loss) # ,␣
 ↪experimental_run_tf_function=False

vae_model.summary()
```

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

 encoder (Functional)        (None, 7)                 432
```

```
 decoder (Functional)        (None, 23)                364

=================================================================
Total params: 796
Trainable params: 796
Non-trainable params: 0
_________________________________________________________________
```

4.2 3.2 Train

[29]:
```
train_start = time.time()

results = vae_model.fit(X_train_VAE, X_train_VAE,
                        shuffle = True,
                        epochs = epochs,
                        batch_size = batch_size)

train_end = time.time()
train_time = train_end - train_start

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

```
Train on 352643 samples
Epoch 1/100

2023-05-17 11:06:33.614202: 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
2023-05-17 11:06:33.614248: I
tensorflow/compiler/xla/stream_executor/cuda/cuda_diagnostics.cc:168] retrieving
CUDA diagnostic information for host: pop-os
2023-05-17 11:06:33.614258: I
tensorflow/compiler/xla/stream_executor/cuda/cuda_diagnostics.cc:175] hostname:
pop-os
2023-05-17 11:06:33.614413: I
tensorflow/compiler/xla/stream_executor/cuda/cuda_diagnostics.cc:199] libcuda
reported version is: 525.105.17
2023-05-17 11:06:33.614458: I
tensorflow/compiler/xla/stream_executor/cuda/cuda_diagnostics.cc:203] kernel
reported version is: 525.105.17
2023-05-17 11:06:33.614467: I
tensorflow/compiler/xla/stream_executor/cuda/cuda_diagnostics.cc:309] kernel
version seems to match DSO: 525.105.17
2023-05-17 11:06:33.634880: I
tensorflow/compiler/mlir/mlir_graph_optimization_pass.cc:353] MLIR V1
optimization pass is not enabled
2023-05-17 11:06:33.669286: W tensorflow/c/c_api.cc:300] Operation
'{name:'training/Adam/z_mean/bias/m/Assign' id:441 op device:{requested: '',
```

```
assigned: ''} def:{{{node training/Adam/z_mean/bias/m/Assign}} =
AssignVariableOp[_has_manual_control_dependencies=true, dtype=DT_FLOAT,
validate_shape=false](training/Adam/z_mean/bias/m,
training/Adam/z_mean/bias/m/Initializer/zeros)}}' was changed by setting
attribute after it was run by a session. This mutation will have no effect, and
will trigger an error in the future. Either don't modify nodes after running
them or create a new session.

352643/352643 [==============================] - 10s 27us/sample - loss: 34.6176
Epoch 2/100
352643/352643 [==============================] - 9s 26us/sample - loss: 9.0601
Epoch 3/100
352643/352643 [==============================] - 9s 25us/sample - loss: 7.6681
Epoch 4/100
352643/352643 [==============================] - 9s 25us/sample - loss: 6.7238
Epoch 5/100
352643/352643 [==============================] - 9s 26us/sample - loss: 6.0911
Epoch 6/100
352643/352643 [==============================] - 9s 25us/sample - loss: 5.7676
Epoch 7/100
352643/352643 [==============================] - 9s 25us/sample - loss: 5.5763
Epoch 8/100
352643/352643 [==============================] - 9s 25us/sample - loss: 5.4408
Epoch 9/100
352643/352643 [==============================] - 9s 25us/sample - loss: 5.3258
Epoch 10/100
352643/352643 [==============================] - 9s 25us/sample - loss: 5.2470
Epoch 11/100
352643/352643 [==============================] - 9s 25us/sample - loss: 5.1649
Epoch 12/100
352643/352643 [==============================] - 9s 26us/sample - loss: 5.0778
Epoch 13/100
352643/352643 [==============================] - 9s 26us/sample - loss: 5.0129
Epoch 14/100
352643/352643 [==============================] - 9s 25us/sample - loss: 4.9532
Epoch 15/100
352643/352643 [==============================] - 9s 25us/sample - loss: 4.9143
Epoch 16/100
352643/352643 [==============================] - 9s 25us/sample - loss: 4.8839
Epoch 17/100
352643/352643 [==============================] - 9s 25us/sample - loss: 4.8494
Epoch 18/100
352643/352643 [==============================] - 9s 26us/sample - loss: 4.8350
Epoch 19/100
352643/352643 [==============================] - 9s 25us/sample - loss: 4.8243
Epoch 20/100
352643/352643 [==============================] - 9s 25us/sample - loss: 4.8090
Epoch 21/100
```

```
352643/352643 [==============================] - 9s 25us/sample - loss: 4.7962
Epoch 22/100
352643/352643 [==============================] - 9s 25us/sample - loss: 4.7861
Epoch 23/100
352643/352643 [==============================] - 9s 25us/sample - loss: 4.7756
Epoch 24/100
352643/352643 [==============================] - 9s 26us/sample - loss: 4.7653
Epoch 25/100
352643/352643 [==============================] - 9s 25us/sample - loss: 4.7564
Epoch 26/100
352643/352643 [==============================] - 9s 25us/sample - loss: 4.7501
Epoch 27/100
352643/352643 [==============================] - 9s 25us/sample - loss: 4.7546
Epoch 28/100
352643/352643 [==============================] - 9s 25us/sample - loss: 4.7459
Epoch 29/100
352643/352643 [==============================] - 9s 26us/sample - loss: 4.7373
Epoch 30/100
352643/352643 [==============================] - 9s 25us/sample - loss: 4.7346
Epoch 31/100
352643/352643 [==============================] - 9s 25us/sample - loss: 4.7322
Epoch 32/100
352643/352643 [==============================] - 9s 26us/sample - loss: 4.7271
Epoch 33/100
352643/352643 [==============================] - 9s 25us/sample - loss: 4.7122
Epoch 34/100
352643/352643 [==============================] - 9s 25us/sample - loss: 4.7132
Epoch 35/100
352643/352643 [==============================] - 9s 25us/sample - loss: 4.6986
Epoch 36/100
352643/352643 [==============================] - 9s 26us/sample - loss: 4.6967
Epoch 37/100
352643/352643 [==============================] - 9s 25us/sample - loss: 4.6918
Epoch 38/100
352643/352643 [==============================] - 9s 26us/sample - loss: 4.6842
Epoch 39/100
352643/352643 [==============================] - 9s 25us/sample - loss: 4.6723
Epoch 40/100
352643/352643 [==============================] - 9s 26us/sample - loss: 4.6665
Epoch 41/100
352643/352643 [==============================] - 9s 25us/sample - loss: 4.6644
Epoch 42/100
352643/352643 [==============================] - 9s 25us/sample - loss: 4.6661
Epoch 43/100
352643/352643 [==============================] - 9s 25us/sample - loss: 4.6600
Epoch 44/100
352643/352643 [==============================] - 9s 25us/sample - loss: 4.6549
Epoch 45/100
```

```
352643/352643 [==============================] - 9s 26us/sample - loss: 4.6583
Epoch 46/100
352643/352643 [==============================] - 9s 26us/sample - loss: 4.6558
Epoch 47/100
352643/352643 [==============================] - 9s 25us/sample - loss: 4.6511
Epoch 48/100
352643/352643 [==============================] - 9s 26us/sample - loss: 4.6498
Epoch 49/100
352643/352643 [==============================] - 9s 25us/sample - loss: 4.6430
Epoch 50/100
352643/352643 [==============================] - 9s 26us/sample - loss: 4.6397
Epoch 51/100
352643/352643 [==============================] - 9s 25us/sample - loss: 4.6474
Epoch 52/100
352643/352643 [==============================] - 9s 25us/sample - loss: 4.6487
Epoch 53/100
352643/352643 [==============================] - 9s 25us/sample - loss: 4.6383
Epoch 54/100
352643/352643 [==============================] - 9s 26us/sample - loss: 4.6382
Epoch 55/100
352643/352643 [==============================] - 9s 26us/sample - loss: 4.6362
Epoch 56/100
352643/352643 [==============================] - 9s 26us/sample - loss: 4.6355
Epoch 57/100
352643/352643 [==============================] - 9s 25us/sample - loss: 4.6371
Epoch 58/100
352643/352643 [==============================] - 9s 26us/sample - loss: 4.6428
Epoch 59/100
352643/352643 [==============================] - 9s 25us/sample - loss: 4.6371
Epoch 60/100
352643/352643 [==============================] - 9s 26us/sample - loss: 4.6353
Epoch 61/100
352643/352643 [==============================] - 9s 26us/sample - loss: 4.6422
Epoch 62/100
352643/352643 [==============================] - 9s 26us/sample - loss: 4.6378
Epoch 63/100
352643/352643 [==============================] - 9s 26us/sample - loss: 4.6390
Epoch 64/100
352643/352643 [==============================] - 9s 25us/sample - loss: 4.6430
Epoch 65/100
352643/352643 [==============================] - 9s 25us/sample - loss: 4.6441
Epoch 66/100
352643/352643 [==============================] - 9s 26us/sample - loss: 4.6396
Epoch 67/100
352643/352643 [==============================] - 9s 26us/sample - loss: 4.6414
Epoch 68/100
352643/352643 [==============================] - 9s 26us/sample - loss: 4.6264
Epoch 69/100
```

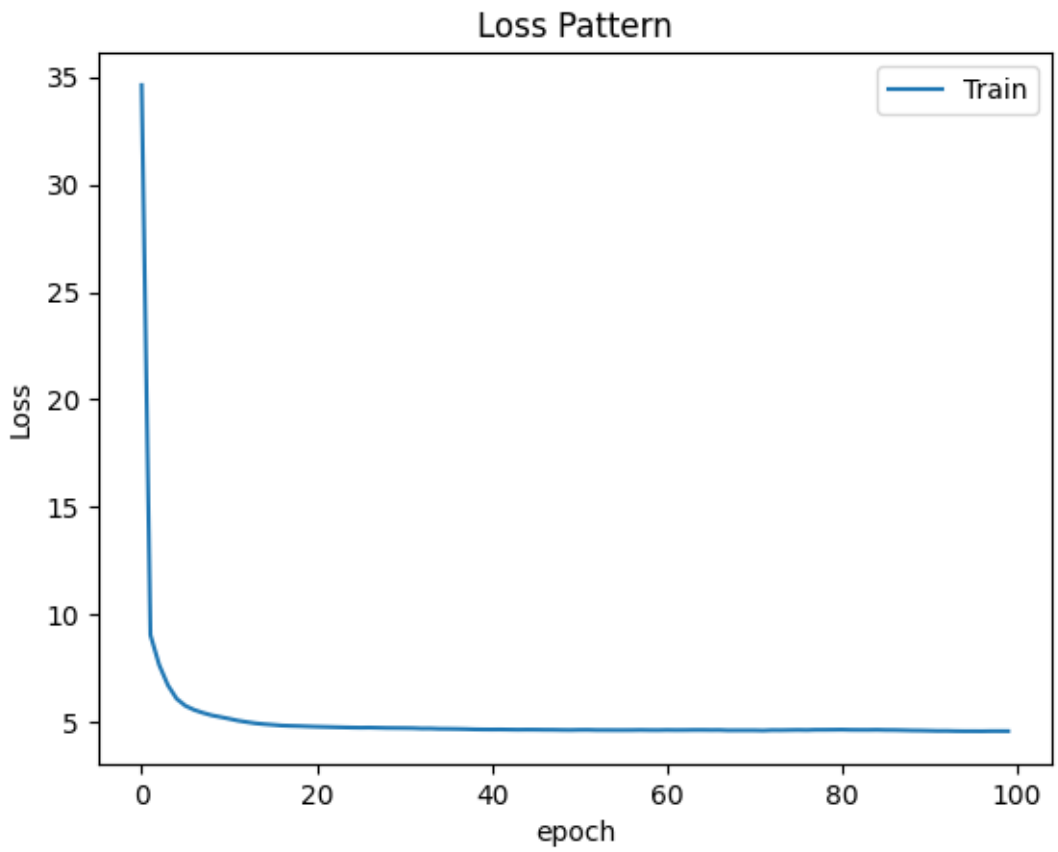
```
352643/352643 [==============================] - 9s 25us/sample - loss: 4.6279
Epoch 70/100
352643/352643 [==============================] - 9s 25us/sample - loss: 4.6278
Epoch 71/100
352643/352643 [==============================] - 9s 25us/sample - loss: 4.6275
Epoch 72/100
352643/352643 [==============================] - 9s 26us/sample - loss: 4.6188
Epoch 73/100
352643/352643 [==============================] - 9s 26us/sample - loss: 4.6354
Epoch 74/100
352643/352643 [==============================] - 9s 25us/sample - loss: 4.6335
Epoch 75/100
352643/352643 [==============================] - 9s 25us/sample - loss: 4.6390
Epoch 76/100
352643/352643 [==============================] - 9s 26us/sample - loss: 4.6447
Epoch 77/100
352643/352643 [==============================] - 9s 26us/sample - loss: 4.6386
Epoch 78/100
352643/352643 [==============================] - 9s 26us/sample - loss: 4.6509
Epoch 79/100
352643/352643 [==============================] - 9s 26us/sample - loss: 4.6508
Epoch 80/100
352643/352643 [==============================] - 9s 25us/sample - loss: 4.6541
Epoch 81/100
352643/352643 [==============================] - 9s 26us/sample - loss: 4.6578
Epoch 82/100
352643/352643 [==============================] - 9s 25us/sample - loss: 4.6483
Epoch 83/100
352643/352643 [==============================] - 9s 26us/sample - loss: 4.6460
Epoch 84/100
352643/352643 [==============================] - 9s 26us/sample - loss: 4.6453
Epoch 85/100
352643/352643 [==============================] - 9s 26us/sample - loss: 4.6504
Epoch 86/100
352643/352643 [==============================] - 9s 26us/sample - loss: 4.6411
Epoch 87/100
352643/352643 [==============================] - 9s 26us/sample - loss: 4.6394
Epoch 88/100
352643/352643 [==============================] - 9s 26us/sample - loss: 4.6308
Epoch 89/100
352643/352643 [==============================] - 9s 26us/sample - loss: 4.6213
Epoch 90/100
352643/352643 [==============================] - 9s 25us/sample - loss: 4.6178
Epoch 91/100
352643/352643 [==============================] - 9s 25us/sample - loss: 4.6095
Epoch 92/100
352643/352643 [==============================] - 9s 25us/sample - loss: 4.6008
Epoch 93/100
```

```
352643/352643 [==============================] - 9s 25us/sample - loss: 4.6019
Epoch 94/100
352643/352643 [==============================] - 9s 25us/sample - loss: 4.5919
Epoch 95/100
352643/352643 [==============================] - 9s 25us/sample - loss: 4.5881
Epoch 96/100
352643/352643 [==============================] - 9s 25us/sample - loss: 4.5879
Epoch 97/100
352643/352643 [==============================] - 9s 25us/sample - loss: 4.5854
Epoch 98/100
352643/352643 [==============================] - 9s 26us/sample - loss: 4.5915
Epoch 99/100
352643/352643 [==============================] - 10s 27us/sample - loss: 4.5914
Epoch 100/100
352643/352643 [==============================] - 10s 28us/sample - loss: 4.5894
Training time:  901.2610259056091
```

[ ]:
```
vae_model.save("vae_model")
saveHist(history_filename, results.history)
```

[ ]:
```
# lstm_model = keras.models.load_model("vae_model")
# history1 = loadHist(history_filename)

# vae_model.summary()

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

[30]:
```
plt.plot(results.history['loss'])
plt.title('Loss Pattern')
plt.ylabel('Loss')
plt.xlabel('epoch')
plt.legend(['Train', 'Test'], loc='upper right');
plt.show()
```



[55]:
```
# Prediction in Train Data
X_train_pred = vae_model.predict(X_train_VAE)
error_vector = get_error_term(X_train_pred, X_train_VAE, _rmse=False)

attacks = (error_vector > anomaly_threshold)
# Measure the error between the train set and its output and generates an error␣
 ↪vector representing the error of each term
# Find an extreme value on the vector to use as the error threshold

# Percentage of attacks predicted in training data
print(f'Attacks Predicted: {np.count_nonzero(attacks == 1) / len(attacks):.6f}')
```

```
Attacks Predicted: 0.091656
```

[57]:
```
# Predicao com dados Benignos (30%) apenas de Teste == Cenário Normal
test_start = time.time()

X_pred_VAE_ = vae_model.predict(X_test_benign)

test_end = time.time()
```

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

error_vector_ = get_error_term(X_pred_VAE_, X_test_benign, _rmse=False)
attacks_ = (error_vector_ > anomaly_threshold)

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

```
Testing time: 2.18s

Attacks Predicted (only benign): 0.114375
```

4.3 3.3 Test

[56]:
```
# Predicao com dados Benignos + Ataque em Teste == Cenário sob Ataque
test_start = time.time()

X_pred_VAE = vae_model.predict(X_test_VAE)

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

# If the error of the vector is higher than the defined threshold it detects an␣
 ↪attack
error_vector = get_error_term(X_pred_VAE, X_test_VAE, _rmse=False)
attacks = (error_vector > anomaly_threshold)

# Percentage of attacks predicted
print(f'Attacks Predicted: \t{np.count_nonzero(attacks) / len(attacks):.6f}')

# Quantidade real de ataques nos dados de teste
print(f'Real Attacks: \t\t{np.count_nonzero(Y_test_VAE == 1) / len(Y_test_VAE):.
 ↪6f}')
```

```
Testing time: 86.47s

Attacks Predicted:      0.977046
Real Attacks:           0.975008
```

4.4 3.4 Metrics

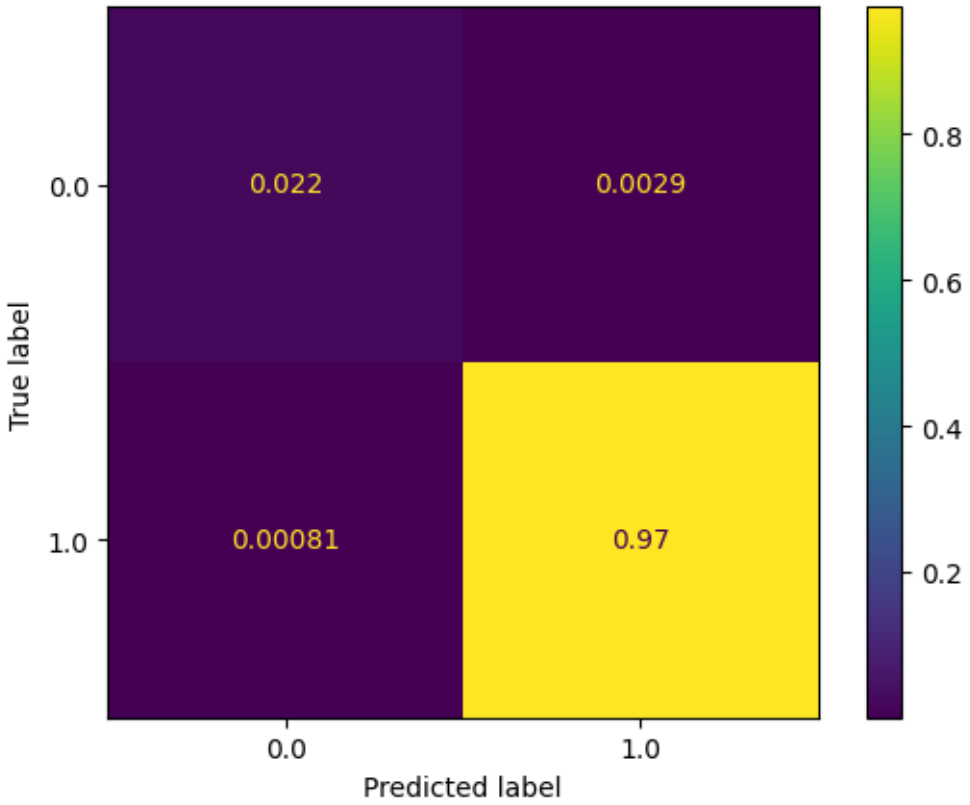
[58]:
```
target_names = ['Benign', 'Attack']

print(f" ==== Test {number_features} features - Normal learning rate ====")
```

```
print(f"Training time: {train_time / 60:.2f} min")
print(f"Testing time: {test_time / 60:.2f} min")
print(classification_report(Y_test_VAE, attacks, target_names=target_names,␣
 ↪digits = 5))
```

```
 ==== Test 23 features - Normal learning rate ====
Training time: 15.02 min
Testing time: 0.04 min
              precision    recall  f1-score   support

      Benign    0.96457   0.88590   0.92356    166784
      Attack    0.99708   0.99917   0.99812   6506674

    accuracy                        0.99634   6673458
   macro avg    0.98083   0.94253   0.96084   6673458
weighted avg    0.99627   0.99634   0.99626   6673458
```

[59]:
```
print(confusion_matrix(Y_test_VAE, attacks))
ConfusionMatrixDisplay.from_predictions(Y_test_VAE, attacks, normalize='all')

plt.show()
```

```
[[ 147754   19030]
 [   5427 6501247]]
```


0.022
0.0029
0.00081
0.97
0.0
1.0
True label
0.0
1.0
Predicted label
0.8
0.6
0.4
0.2

[ ]: