AI for Cyber Secuity network malware detection

Malware Detection using newtork traffic data

Malware:

Malware, short for malicious software, encompasses any software intentionally designed to cause harm to data, devices, or people.

Understanding the data:

The datasets in this notebook were taken from the given huggingface repository

Link: https://huggingface.co/Sellibro/Malware_Detection_with_Deep_Learning/tree/main

The data contains two files

- malicious_flows.csv
- sample_benign_flows.csv

The data is curated on a private network with simulated malware attacks in the network. The CSV files shows data collected from network monitoring, packet tracing and specific malware signature detection.

the data comprises of 16,467 entries and 439 features per entry for the malicious_flows.csv file and 24,999 enteries and 439 features per entry for the sample_benign_flows.csv file.

Some of the columns are

1. **Src_Port:** port number on the source device
2. **Dst_Port:** port number on the destination device
3. **Bytes_in:** number of bytes transferred from the source to the destination
4. **Bytes_out:** number of bytes transferred from the destination back to the source
5. **Pkts_in:** number of packets received by the destination
6. **Pkts_out:** number of packets sent from the destination
7. **entropy:** measure of randomness or unpredictability in the data flow
8. **byte_dist_std:** Byte Distribution Standard Deviation
9. **byte_dist_mn:** Byte Distribution Mean
10. **num_of_exts:** Number of Extensions
11. **isMalware:** 1 for malicious, 0 for benign

12. Rest of the columns represent a specific signature of the malware which can be monitored indipendently for different types of malwares

Data Exploration

```
import pandas as pd

# importing the datasets
malicious_flows = pd.read_csv('malicious_flows.csv')
benign_flows = pd.read_csv('sample_benign_flows.csv')

# Mark each dataset with an additional 'Type' column for readability
malicious_flows['Type'] = 'Malicious'
benign_flows['Type'] = 'Benign'


# getting the first 10 rows of the malicious_flows
malicious_flows.head(10)
```

	Src_Port	Dst_Port	Bytes_in	Bytes_out	Pkts_in	Pkts_out	entropy	byte_dist_std
0	49754	443	6856	870	16	18	5.153654	66.668114
1	49769	449	1578	638	9	8	7.672271	60.441052
2	49777	449	1541	568	8	6	7.676815	61.857156
3	49776	80	106	22083	55	221	12.494184	71.578102
4	49777	9101	25963	2536	34	21	2.305200	68.092069
5	49778	9001	49690	53773	13	79	3.375005	62.542731
6	49779	443	26006	36356	21	245	3.782769	61.942214
7	49780	443	21628	42978	241	232	4.115460	62.302936
8	1035	443	64098	22089	69	96	4.060606	71.592944
9	1036	443	26008	2532	33	21	2.302427	67.811592

10 rows × 440 columns

```
# getting the forst 10 rows of the benign_flows
benign_flows.head(10)
```

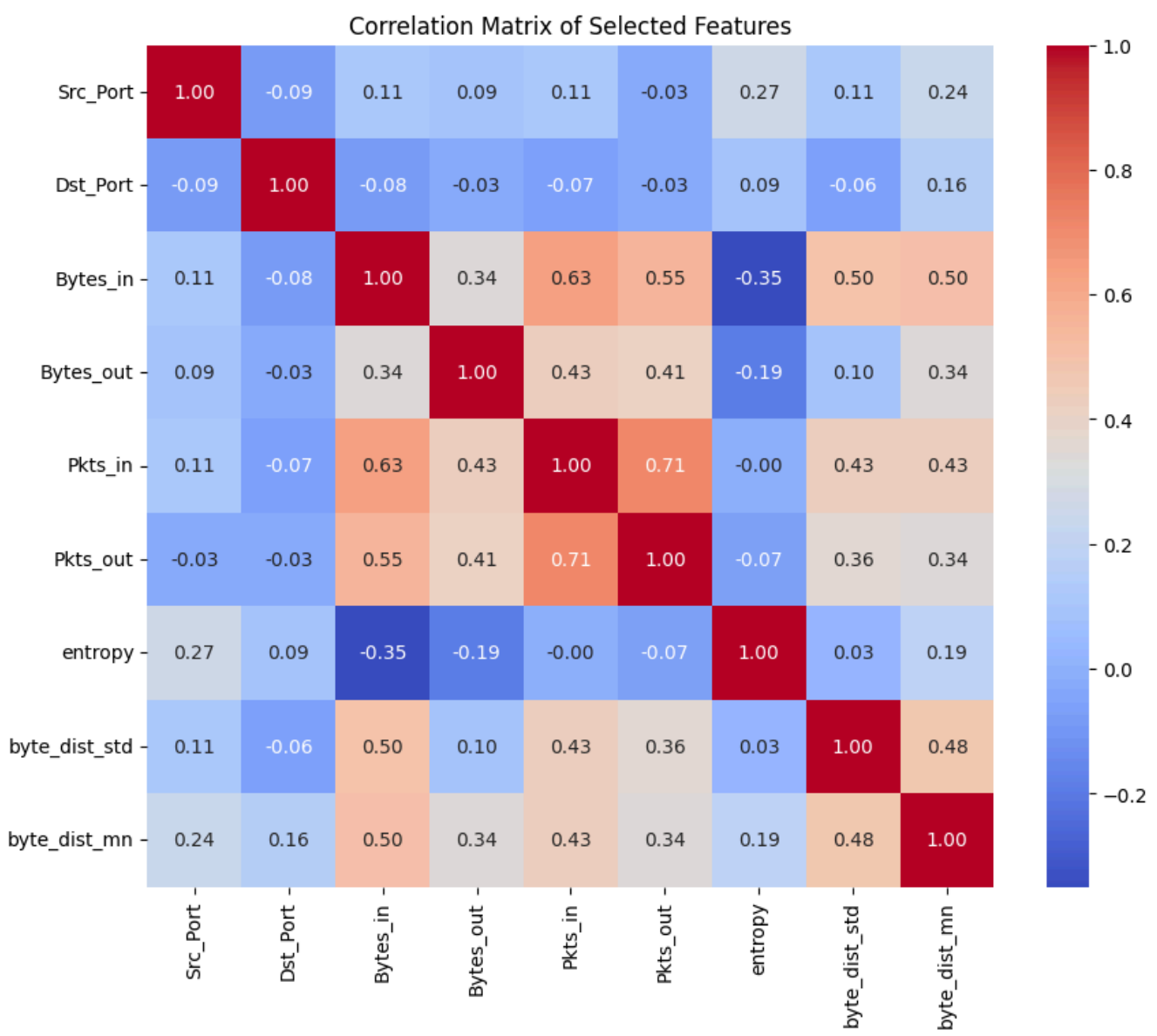
	Src_Port	Dst_Port	Bytes_in	Bytes_out	Pkts_in	Pkts_out	entropy	byte_dist_std
0	1575	443	2530	494	6	8	7.465267	60.798290
1	1576	443	3948	6354	10	12	6.373383	54.101357
2	34355	636	1680	692	9	15	3.888987	60.330783
3	43235	8443	1681	1599	8	15	7.668980	56.882780
4	32913	8443	2602	979	7	15	7.720317	60.221816
5	44779	636	1680	684	9	15	3.885715	59.760488
6	44705	8443	1738	1219	8	15	7.804832	56.057041
7	44839	8443	2645	643	7	15	7.842029	63.773293
8	37554	443	1542	674	8	17	3.824009	57.833506
9	54832	443	11581	10993	174	35	1.316105	66.403926

10 rows × 440 columns

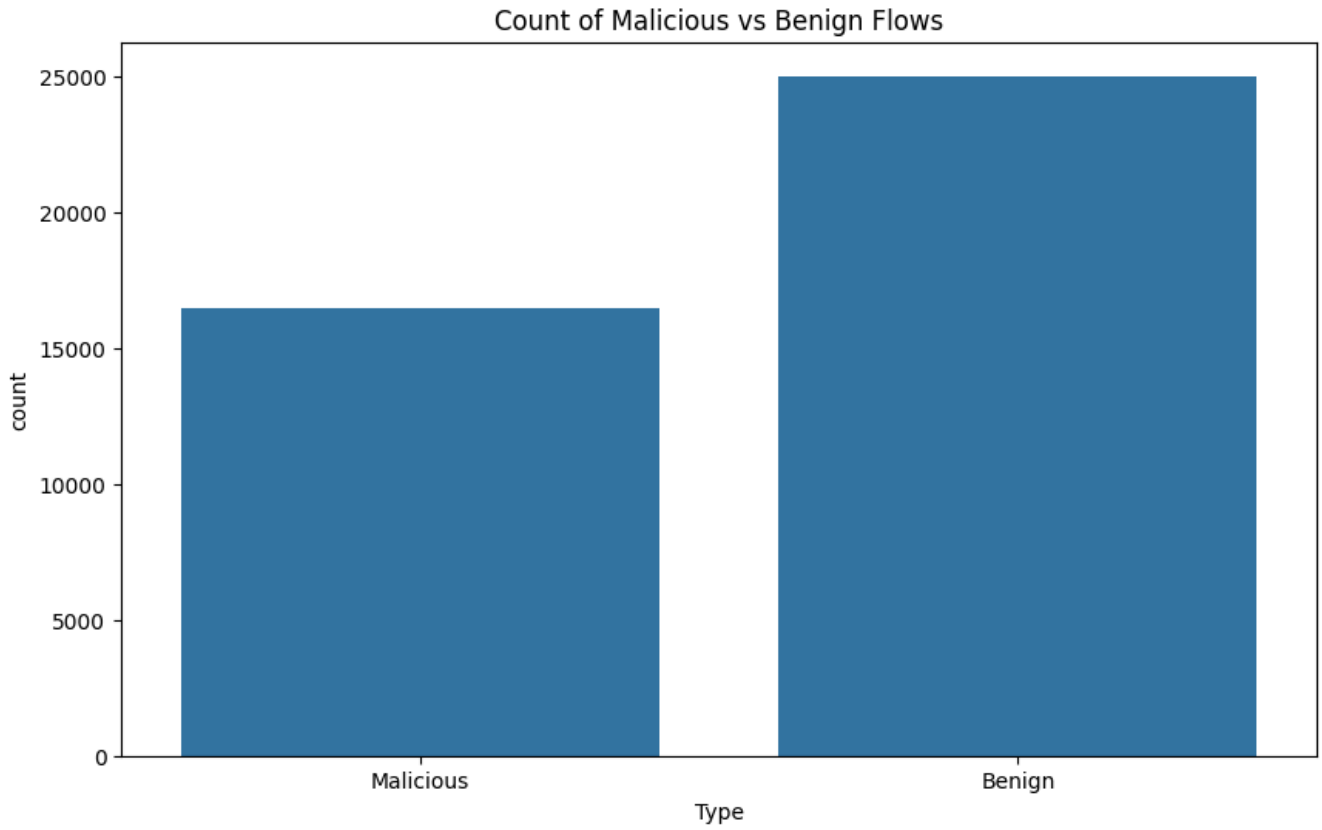
```
# Combine the malicious_flows and benign_flows data
combined_flows = pd.concat([malicious_flows, benign_flows], ignore_index=True)


# Select a subset of features for analysis
features_subset = ['Src_Port', 'Dst_Port', 'Bytes_in', 'Bytes_out', 'Pkts_in', 'Pkts_out',
combined_flows_subset = combined_flows[features_subset]


# Perform a basic correlation analysis on the numerical features
correlation_matrix = combined_flows_subset.select_dtypes(include=['float64', 'int64']).corr
correlation_matrix
```

	Src_Port	Dst_Port	Bytes_in	Bytes_out	Pkts_in	Pkts_out	entropy	by
Src_Port	1.000000	-0.085198	0.109526	0.086988	0.110666	-0.028254	0.267124	
Dst_Port	-0.085198	1.000000	-0.078761	-0.031460	-0.069272	-0.030452	0.093518	
Bytes_in	0.109526	-0.078761	1.000000	0.338144	0.626559	0.549252	-0.349102	
Bytes_out	0.086988	-0.031460	0.338144	1.000000	0.427473	0.408981	-0.193971	
Pkts_in	0.110666	-0.069272	0.626559	0.427473	1.000000	0.711964	-0.002071	
Pkts_out	-0.028254	-0.030452	0.549252	0.408981	0.711964	1.000000	-0.074511	
entropy	0.267124	0.093518	-0.349102	-0.193971	-0.002071	-0.074511	1.000000	
byte_dist_std	0.108268	-0.057031	0.498574	0.096254	0.427756	0.360690	0.026144	
byte_dist_mn	0.243267	0.156248	0.504306	0.341696	0.429608	0.339333	0.188925	

```
import matplotlib.pyplot as plt
import seaborn as sns

# Plotting the correlation matrix
plt.figure(figsize=(10, 8))
sns.heatmap(correlation_matrix, annot=True, fmt=".2f", cmap='coolwarm')
plt.title('Correlation Matrix of Selected Features')
plt.show()
```




```
# Count plot for flow types
plt.figure(figsize=(10, 6))
sns.countplot(x='Type', data=combined_flows_subset)
plt.title('Count of Malicious vs Benign Flows')
plt.show()
```



Data Preprocessing

```
#Importing malicious and benign Datasets
malicious_dataset = pd.read_csv('malicious_flows.csv')
benign_dataset = pd.read_csv('sample_benign_flows.csv')


# Combining both datasets together
all_flows = pd.concat([malicious_dataset, benign_dataset])


# Removing duplicated rows from benign_dataset (5380 rows removed)
benign_dataset = benign_dataset[benign_dataset.duplicated(keep=False) == False]
```

```
import numpy as np

#dataset with columns with nan values dropped
df = all_flows.drop(all_flows.columns[np.isnan(all_flows).any()], axis=1)


# seterating indipendent variable from depencdent variable
reduced_y = df['isMalware']
reduced_x = df.drop(['isMalware'], axis=1)
```

Data Normalization

```
from sklearn import preprocessing

#scale data between 0 and 1
min_max_scaler = preprocessing.MinMaxScaler()
x_scale = min_max_scaler.fit_transform(reduced_x)
```

Data Splitting

```
from sklearn.model_selection import train_test_split

# Splitting datasets into training and test data
x_train, x_test, y_train, y_test = train_test_split(x_scale, reduced_y, test_size=0.2, rand
```

Baseline Model

```
from sklearn.linear_model import LogisticRegression

# Initialize the Logistic Regression model
logreg_model = LogisticRegression(max_iter=200, random_state=42)

# Train the model on the training set
logreg_model.fit(x_train, y_train)
```

```
▾ LogisticRegression
LogisticRegression(max_iter=200, random_state=42)
```

```
from sklearn.metrics import accuracy_score, r2_score, confusion_matrix, mean_absolute_error

# Predict the labels of the test set
y_pred = logreg_model.predict(x_test)

# Evaluate the model
logreg_accuracy = accuracy_score(y_test, y_pred)
logreg_accuracy
```

```
0.9974203534115826
```

Random Forest Classifier

```
from sklearn.ensemble import RandomForestClassifier

# Initialize the Random Forest classifier
clf_model = RandomForestClassifier(n_estimators=100, random_state=42)

# Train the classifier on the training set
clf_model.fit(x_train, y_train)
```

```
RandomForestClassifier
RandomForestClassifier(random_state=42)
```

```
# Predict the labels of the test set
y_pred = clf_model.predict(x_test)

# Evaluate the classifier
clf_accuracy = accuracy_score(y_test, y_pred)
clf_accuracy
```

```
0.9993550883528957
```

```
from sklearn.model_selection import cross_val_score

# Perform k-fold cross-validation
k = 6
clf_cross_validation_scores = cross_val_score(clf, x_test, y_test, cv=k)


# Calculate and print the average score across all folds
cross_validaion_average_score = clf_cross_validation_scores.mean()
cross_validaion_average_score
```

```
0.9981943137494342
```

ANN Model

```
import tensorflow as tf

# model generation
model = tf.keras.Sequential([
    tf.keras.layers.Dense(32, activation ='relu', input_shape=(438,)),
    tf.keras.layers.Dense(32, activation = 'relu'),
    tf.keras.layers.Dense(1, activation = 'sigmoid'),
])


#comipling the model
model.compile(optimizer ='adam',
        loss = 'binary_crossentropy',
        metrics = ['accuracy'])


# visualizing the model
model.summary()
```

```
Model: "sequential_2"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_6 (Dense)             (None, 32)                14048

 dense_7 (Dense)             (None, 32)                1056

 dense_8 (Dense)             (None, 1)                 33

=================================================================
Total params: 15137 (59.13 KB)
Trainable params: 15137 (59.13 KB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
```

```
# fitting the model on the dataset
history = model.fit(x_train, y_train, batch_size=32, epochs = 5 ,verbose=1, validation_data
```

```
Epoch 1/5
970/970 [==============================] - 4s 3ms/step - loss: 0.0390 - accuracy: 0.986
Epoch 2/5
970/970 [==============================] - 3s 3ms/step - loss: 0.0098 - accuracy: 0.996
Epoch 3/5
970/970 [==============================] - 6s 6ms/step - loss: 0.0079 - accuracy: 0.997
Epoch 4/5
970/970 [==============================] - 7s 7ms/step - loss: 0.0074 - accuracy: 0.997
Epoch 5/5
970/970 [==============================] - 8s 8ms/step - loss: 0.0064 - accuracy: 0.998
```

```
#evaluating the model
ANN_model_accuracy = model.evaluate(x_test, y_test)
ANN_model_accuracy
```

```
243/243 [==============================] - 2s 7ms/step - loss: 0.0089 - accuracy: 0.997
[0.00886229332536459, 0.9978073239326477]
```

Evaluating different models

```
logreg_accuracy, cross_validaion_average_score, ANN_model_accuracy
```

```
(0.9974203534115826,
 0.9981943137494342,
 [0.00886229332536459, 0.9978073239326477])
```

```
# names of all the models
models = ['Logistic Regression', 'Cross Validation Random Forest Classifier', 'Artificial N

# Accuracy values
accuracies = [logreg_accuracy, cross_validaion_average_score, ANN_model_accuracy[1]]

# Plotting the comparison graph
plt.figure(figsize=(8, 6))
plt.bar(models, accuracies)
plt.ylabel('Accuracy')
plt.title('Models')
```