cs-neural-network

May 20, 2023

[4]:
```
pip install keras scikit-learn matplotlib
```

```
Collecting keras
  Downloading keras-2.12.0-py2.py3-none-any.whl (1.7 MB)
     ---------------------------------------- 1.7/1.7 MB 3.8 MB/s eta 0:00:00
Requirement already satisfied: scikit-learn in
c:\users\pappu\anaconda3\lib\site-packages (1.0.2)
Requirement already satisfied: matplotlib in c:\users\pappu\anaconda3\lib\site-
packages (3.5.2)
Requirement already satisfied: threadpoolctl>=2.0.0 in
c:\users\pappu\anaconda3\lib\site-packages (from scikit-learn) (2.2.0)
Requirement already satisfied: numpy>=1.14.6 in
c:\users\pappu\anaconda3\lib\site-packages (from scikit-learn) (1.21.5)
Requirement already satisfied: joblib>=0.11 in
c:\users\pappu\anaconda3\lib\site-packages (from scikit-learn) (1.2.0)
Requirement already satisfied: scipy>=1.1.0 in
c:\users\pappu\anaconda3\lib\site-packages (from scikit-learn) (1.9.1)
Requirement already satisfied: kiwisolver>=1.0.1 in
c:\users\pappu\anaconda3\lib\site-packages (from matplotlib) (1.4.2)
Requirement already satisfied: pyparsing>=2.2.1 in
c:\users\pappu\anaconda3\lib\site-packages (from matplotlib) (3.0.9)
Requirement already satisfied: cycler>=0.10 in
c:\users\pappu\anaconda3\lib\site-packages (from matplotlib) (0.11.0)
Requirement already satisfied: fonttools>=4.22.0 in
c:\users\pappu\anaconda3\lib\site-packages (from matplotlib) (4.25.0)
Requirement already satisfied: python-dateutil>=2.7 in
c:\users\pappu\anaconda3\lib\site-packages (from matplotlib) (2.8.2)
Requirement already satisfied: pillow>=6.2.0 in
c:\users\pappu\anaconda3\lib\site-packages (from matplotlib) (9.2.0)
Requirement already satisfied: packaging>=20.0 in
c:\users\pappu\anaconda3\lib\site-packages (from matplotlib) (21.3)
Requirement already satisfied: six>=1.5 in c:\users\pappu\anaconda3\lib\site-
packages (from python-dateutil>=2.7->matplotlib) (1.16.0)
Installing collected packages: keras
Successfully installed keras-2.12.0
Note: you may need to restart the kernel to use updated packages.
```

[7]:
```
pip install tensorflow
```

```
Collecting tensorflow
  Downloading tensorflow-2.12.0-cp39-cp39-win_amd64.whl (1.9 kB)
Collecting tensorflow-intel==2.12.0
  Downloading tensorflow_intel-2.12.0-cp39-cp39-win_amd64.whl (272.8 MB)
     ---------------------------------------- 272.8/272.8 MB 4.9 MB/s eta 0:00:00
Requirement already satisfied: six>=1.12.0 in c:\users\pappu\anaconda3\lib\site-
packages (from tensorflow-intel==2.12.0->tensorflow) (1.16.0)
Collecting jax>=0.3.15
  Downloading jax-0.4.10.tar.gz (1.3 MB)
     ---------------------------------------- 1.3/1.3 MB 10.1 MB/s eta 0:00:00
  Installing build dependencies: started
  Installing build dependencies: finished with status 'done'
  Getting requirements to build wheel: started
  Getting requirements to build wheel: finished with status 'done'
  Preparing metadata (pyproject.toml): started
  Preparing metadata (pyproject.toml): finished with status 'done'
Collecting gast<=0.4.0,>=0.2.1
  Downloading gast-0.4.0-py3-none-any.whl (9.8 kB)
Requirement already satisfied: h5py>=2.9.0 in c:\users\pappu\anaconda3\lib\site-
packages (from tensorflow-intel==2.12.0->tensorflow) (3.7.0)
Requirement already satisfied: setuptools in c:\users\pappu\anaconda3\lib\site-
packages (from tensorflow-intel==2.12.0->tensorflow) (63.4.1)
Collecting tensorboard<2.13,>=2.12
  Downloading tensorboard-2.12.3-py3-none-any.whl (5.6 MB)
     ---------------------------------------- 5.6/5.6 MB 10.3 MB/s eta 0:00:00
Collecting termcolor>=1.1.0
  Downloading termcolor-2.3.0-py3-none-any.whl (6.9 kB)
Requirement already satisfied: packaging in c:\users\pappu\anaconda3\lib\site-
packages (from tensorflow-intel==2.12.0->tensorflow) (21.3)
Collecting tensorflow-io-gcs-filesystem>=0.23.1
  Downloading tensorflow_io_gcs_filesystem-0.31.0-cp39-cp39-win_amd64.whl (1.5
MB)
     ---------------------------------------- 1.5/1.5 MB 9.5 MB/s eta 0:00:00
Collecting grpcio<2.0,>=1.24.3
  Downloading grpcio-1.54.2-cp39-cp39-win_amd64.whl (4.1 MB)
     ---------------------------------------- 4.1/4.1 MB 10.1 MB/s eta 0:00:00
Collecting
protobuf!=4.21.0,!=4.21.1,!=4.21.2,!=4.21.3,!=4.21.4,!=4.21.5,<5.0.0dev,>=3.20.3
  Downloading protobuf-4.23.1-cp39-cp39-win_amd64.whl (422 kB)
     ---------------------------------------- 422.5/422.5 kB 8.8 MB/s eta 0:00:00
Collecting flatbuffers>=2.0
  Downloading flatbuffers-23.5.9-py2.py3-none-any.whl (26 kB)
Collecting astunparse>=1.6.0
  Downloading astunparse-1.6.3-py2.py3-none-any.whl (12 kB)
Collecting numpy<1.24,>=1.22
  Downloading numpy-1.23.5-cp39-cp39-win_amd64.whl (14.7 MB)
     ---------------------------------------- 14.7/14.7 MB 9.6 MB/s eta 0:00:00
Requirement already satisfied: wrapt<1.15,>=1.11.0 in
```

```
c:\users\pappu\anaconda3\lib\site-packages (from tensorflow-
intel==2.12.0->tensorflow) (1.14.1)
Collecting opt-einsum>=2.3.2
  Downloading opt_einsum-3.3.0-py3-none-any.whl (65 kB)
     ---------------------------------------- 65.5/65.5 kB 3.5 MB/s eta 0:00:00
Collecting libclang>=13.0.0
  Downloading libclang-16.0.0-py2.py3-none-win_amd64.whl (24.4 MB)
     ---------------------------------------- 24.4/24.4 MB 10.5 MB/s eta 0:00:00
Collecting tensorflow-estimator<2.13,>=2.12.0
  Downloading tensorflow_estimator-2.12.0-py2.py3-none-any.whl (440 kB)
     ---------------------------------------- 440.7/440.7 kB 9.2 MB/s eta 0:00:00
Collecting absl-py>=1.0.0
  Downloading absl_py-1.4.0-py3-none-any.whl (126 kB)
     ---------------------------------------- 126.5/126.5 kB ? eta 0:00:00
Collecting google-pasta>=0.1.1
  Downloading google_pasta-0.2.0-py3-none-any.whl (57 kB)
     ---------------------------------------- 57.5/57.5 kB 3.1 MB/s eta 0:00:00
Requirement already satisfied: typing-extensions>=3.6.6 in
c:\users\pappu\anaconda3\lib\site-packages (from tensorflow-
intel==2.12.0->tensorflow) (4.3.0)
Requirement already satisfied: keras<2.13,>=2.12.0 in
c:\users\pappu\anaconda3\lib\site-packages (from tensorflow-
intel==2.12.0->tensorflow) (2.12.0)
Requirement already satisfied: wheel<1.0,>=0.23.0 in
c:\users\pappu\anaconda3\lib\site-packages (from astunparse>=1.6.0->tensorflow-
intel==2.12.0->tensorflow) (0.37.1)
Collecting ml-dtypes>=0.1.0
  Downloading ml_dtypes-0.1.0-cp39-cp39-win_amd64.whl (120 kB)
     ---------------------------------------- 120.3/120.3 kB 7.3 MB/s eta 0:00:00
Requirement already satisfied: scipy>=1.7 in c:\users\pappu\anaconda3\lib\site-
packages (from jax>=0.3.15->tensorflow-intel==2.12.0->tensorflow) (1.9.1)
Collecting google-auth<3,>=1.6.3
  Downloading google_auth-2.18.1-py2.py3-none-any.whl (178 kB)
     ---------------------------------------- 178.9/178.9 kB ? eta 0:00:00
Requirement already satisfied: requests<3,>=2.21.0 in
c:\users\pappu\anaconda3\lib\site-packages (from
tensorboard<2.13,>=2.12->tensorflow-intel==2.12.0->tensorflow) (2.28.1)
Collecting tensorboard-data-server<0.8.0,>=0.7.0
  Downloading tensorboard_data_server-0.7.0-py3-none-any.whl (2.4 kB)
Collecting google-auth-oauthlib<1.1,>=0.5
  Downloading google_auth_oauthlib-1.0.0-py2.py3-none-any.whl (18 kB)
Requirement already satisfied: werkzeug>=1.0.1 in
c:\users\pappu\anaconda3\lib\site-packages (from
tensorboard<2.13,>=2.12->tensorflow-intel==2.12.0->tensorflow) (2.0.3)
Requirement already satisfied: markdown>=2.6.8 in
c:\users\pappu\anaconda3\lib\site-packages (from
tensorboard<2.13,>=2.12->tensorflow-intel==2.12.0->tensorflow) (3.3.4)
Requirement already satisfied: pyparsing!=3.0.5,>=2.0.2 in
```

```
c:\users\pappu\anaconda3\lib\site-packages (from packaging->tensorflow-
intel==2.12.0->tensorflow) (3.0.9)
Requirement already satisfied: pyasn1-modules>=0.2.1 in
c:\users\pappu\anaconda3\lib\site-packages (from google-
auth<3,>=1.6.3->tensorboard<2.13,>=2.12->tensorflow-intel==2.12.0->tensorflow)
(0.2.8)
Collecting rsa<5,>=3.1.4
  Downloading rsa-4.9-py3-none-any.whl (34 kB)
Requirement already satisfied: urllib3<2.0 in c:\users\pappu\anaconda3\lib\site-
packages (from google-auth<3,>=1.6.3->tensorboard<2.13,>=2.12->tensorflow-
intel==2.12.0->tensorflow) (1.26.11)
Collecting cachetools<6.0,>=2.0.0
  Downloading cachetools-5.3.0-py3-none-any.whl (9.3 kB)
Collecting requests-oauthlib>=0.7.0
  Downloading requests_oauthlib-1.3.1-py2.py3-none-any.whl (23 kB)
Requirement already satisfied: charset-normalizer<3,>=2 in
c:\users\pappu\anaconda3\lib\site-packages (from
requests<3,>=2.21.0->tensorboard<2.13,>=2.12->tensorflow-
intel==2.12.0->tensorflow) (2.0.4)
Requirement already satisfied: certifi>=2017.4.17 in
c:\users\pappu\anaconda3\lib\site-packages (from
requests<3,>=2.21.0->tensorboard<2.13,>=2.12->tensorflow-
intel==2.12.0->tensorflow) (2022.9.14)
Requirement already satisfied: idna<4,>=2.5 in
c:\users\pappu\anaconda3\lib\site-packages (from
requests<3,>=2.21.0->tensorboard<2.13,>=2.12->tensorflow-
intel==2.12.0->tensorflow) (3.3)
Requirement already satisfied: pyasn1<0.5.0,>=0.4.6 in
c:\users\pappu\anaconda3\lib\site-packages (from pyasn1-modules>=0.2.1->google-
auth<3,>=1.6.3->tensorboard<2.13,>=2.12->tensorflow-intel==2.12.0->tensorflow)
(0.4.8)
Collecting oauthlib>=3.0.0
  Downloading oauthlib-3.2.2-py3-none-any.whl (151 kB)
     ---------------------------------------- 151.7/151.7 kB ? eta 0:00:00
Building wheels for collected packages: jax
  Building wheel for jax (pyproject.toml): started
  Building wheel for jax (pyproject.toml): finished with status 'done'
  Created wheel for jax: filename=jax-0.4.10-py3-none-any.whl size=1480617
sha256=e52d732c5936b9a6a0553e07ecac2673924066c141b114d76d42cb50c6060803
  Stored in directory: c:\users\pappu\appdata\local\pip\cache\wheels\e5\6c\70\7c
6be85fa56f05480fe043bdf0d4f6ec316b122be21e098066
Successfully built jax
Installing collected packages: libclang, flatbuffers, termcolor, tensorflow-io-
gcs-filesystem, tensorflow-estimator, tensorboard-data-server, rsa, protobuf,
oauthlib, numpy, grpcio, google-pasta, gast, cachetools, astunparse, absl-py,
requests-oauthlib, opt-einsum, ml-dtypes, google-auth, jax, google-auth-
oauthlib, tensorboard, tensorflow-intel, tensorflow
  Attempting uninstall: numpy
```

```
    Found existing installation: numpy 1.21.5
    Uninstalling numpy-1.21.5:
      Successfully uninstalled numpy-1.21.5
Successfully installed absl-py-1.4.0 astunparse-1.6.3 cachetools-5.3.0
flatbuffers-23.5.9 gast-0.4.0 google-auth-2.18.1 google-auth-oauthlib-1.0.0
google-pasta-0.2.0 grpcio-1.54.2 jax-0.4.10 libclang-16.0.0 ml-dtypes-0.1.0
numpy-1.23.5 oauthlib-3.2.2 opt-einsum-3.3.0 protobuf-4.23.1 requests-
oauthlib-1.3.1 rsa-4.9 tensorboard-2.12.3 tensorboard-data-server-0.7.0
tensorflow-2.12.0 tensorflow-estimator-2.12.0 tensorflow-intel-2.12.0
tensorflow-io-gcs-filesystem-0.31.0 termcolor-2.3.0
Note: you may need to restart the kernel to use updated packages.
```

```
ERROR: pip's dependency resolver does not currently take into account all the
packages that are installed. This behaviour is the source of the following
dependency conflicts.
daal4py 2021.6.0 requires daal==2021.4.0, which is not installed.
numba 0.55.1 requires numpy<1.22,>=1.18, but you have numpy 1.23.5 which is
incompatible.
```

[21]:
```python
import pandas as pd
import numpy as np
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import LabelEncoder, StandardScaler
from sklearn.metrics import accuracy_score, precision_score, recall_score,␣
 ↪f1_score, confusion_matrix, classification_report
import matplotlib.pyplot as plt
from keras.models import Sequential
from keras.layers import Dense
from keras.utils import np_utils

# Load the dataset
df = pd.read_csv('preprocessed_dataset.csv')

# Map label values to corresponding attack names
label_mapping = {
    0: 'BENIGN',
    1: 'Web Attack: Brute Force',
    2: 'Web Attack: SQL Injection',
    3: 'Web Attack: XSS'
}
df['Label'] = df['Label'].map(label_mapping)

# Split the dataset into features (X) and labels (y)
X = df.iloc[:, :-1]  # All columns except the last one
y = df.iloc[:, -1]   # Last column (labels)

# Encode labels into numerical values
label_encoder = LabelEncoder()
```

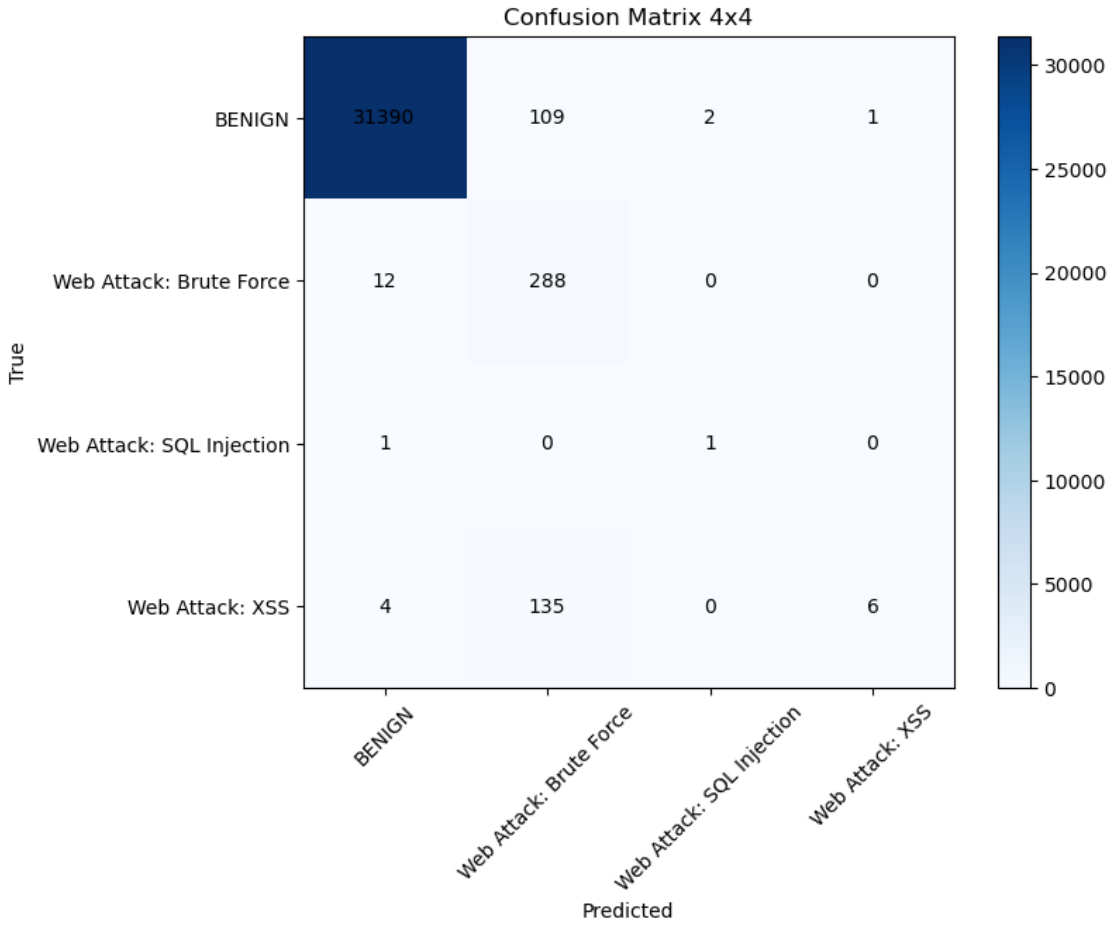
```
y_encoded = label_encoder.fit_transform(y)
y_categorical = np_utils.to_categorical(y_encoded)

# Split the dataset into training and testing sets
X_train, X_test, y_train, y_test = train_test_split(X, y_categorical,␣
 ↪test_size=0.2, random_state=42)

# Create a StandardScaler object
scaler = StandardScaler()

# Fit the scaler on the training set and transform both the training and test␣
 ↪sets
X_train_scaled = scaler.fit_transform(X_train)
X_test_scaled = scaler.transform(X_test)

# Create and train the Neural Network model
model = Sequential()
model.add(Dense(64, input_dim=X_train_scaled.shape[1], activation='relu'))
model.add(Dense(32, activation='relu'))
model.add(Dense(4, activation='softmax'))  # 4 output classes
model.compile(loss='categorical_crossentropy', optimizer='adam',␣
 ↪metrics=['accuracy'])
model.fit(X_train_scaled, y_train, epochs=10, batch_size=32)

# Predict the test set
y_pred_prob = model.predict(X_test_scaled)
y_pred_labels = np.argmax(y_pred_prob, axis=1)
y_pred_labels = label_encoder.inverse_transform(y_pred_labels)

# Convert one-hot encoded y_test back to labels
y_test_labels = label_encoder.inverse_transform(np.argmax(y_test, axis=1))

# Evaluate the model
accuracy = accuracy_score(y_test_labels, y_pred_labels)
precision = precision_score(y_test_labels, y_pred_labels, average='weighted')
recall = recall_score(y_test_labels, y_pred_labels, average='weighted')
f1 = f1_score(y_test_labels, y_pred_labels, average='weighted')
confusion_matrix_4x4 = confusion_matrix(y_test_labels, y_pred_labels)

# Calculate values for the 2x2 confusion matrix
TN = confusion_matrix_4x4[0, 0]  # True Negatives (0, 0)
FP = np.sum(confusion_matrix_4x4[0, 1:])  # False Positives (0, 1+2+3)
FN = np.sum(confusion_matrix_4x4[1:, 0])  # False Negatives (1+2+3, 0)
TP = np.sum(confusion_matrix_4x4[1:, 1:])  # True Positives (1+2+3, 1+2+3)
confusion_matrix_2x2 = np.array([[TN, FP], [FN, TP]])

classification = classification_report(y_test_labels, y_pred_labels)
```

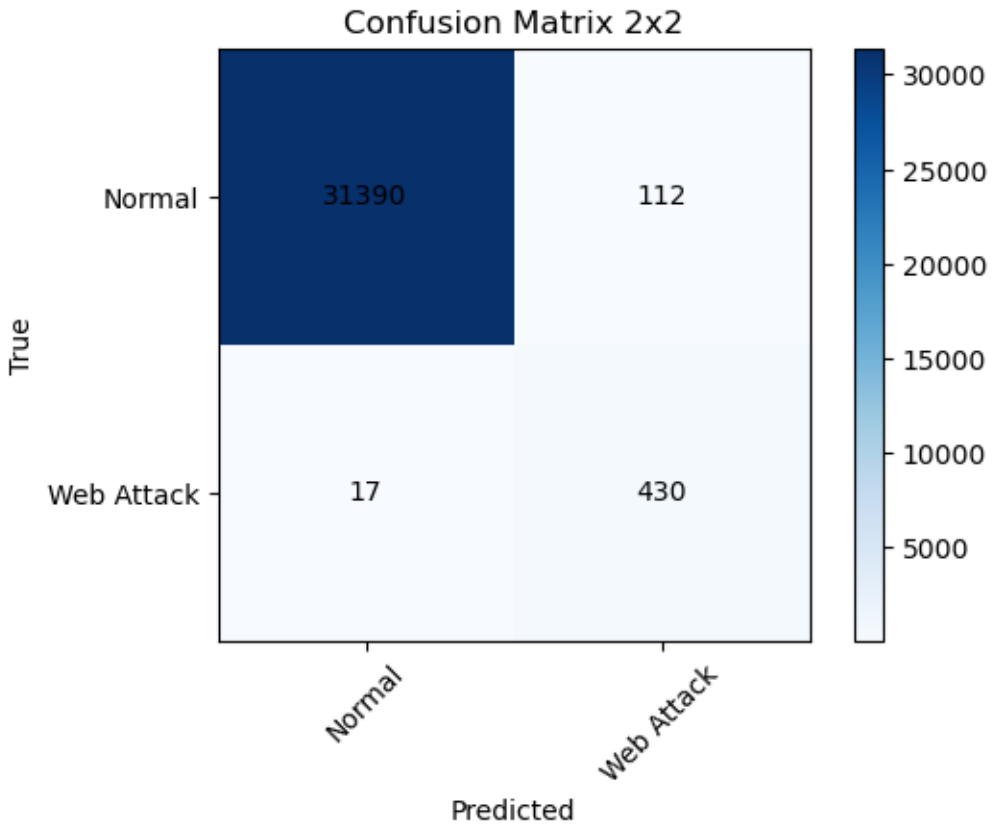
```
# Plot the confusion matrix 4x4
plt.figure(figsize=(8, 6))
plt.imshow(confusion_matrix_4x4, interpolation='nearest', cmap=plt.cm.Blues)
plt.title('Confusion Matrix 4x4')
plt.colorbar()
tick_marks = np.arange(4)
plt.xticks(tick_marks, ['BENIGN', 'Web Attack: Brute Force', 'Web Attack: SQL␣
 ↪Injection', 'Web Attack: XSS'], rotation=45)
plt.yticks(tick_marks, ['BENIGN', 'Web Attack: Brute Force', 'Web Attack: SQL␣
 ↪Injection', 'Web Attack: XSS'])
plt.xlabel('Predicted')
plt.ylabel('True')
for i in range(4):
    for j in range(4):
        plt.text(j, i, str(confusion_matrix_4x4[i, j]),␣
 ↪horizontalalignment='center', verticalalignment='center')

# Plot the confusion matrix 2x2
plt.figure(figsize=(6, 4))
plt.imshow(confusion_matrix_2x2, interpolation='nearest', cmap=plt.cm.Blues)
plt.title('Confusion Matrix 2x2')
plt.colorbar()
tick_marks = np.arange(2)
plt.xticks(tick_marks, ['Normal', 'Web Attack'], rotation=45)
plt.yticks(tick_marks, ['Normal', 'Web Attack'])
plt.xlabel('Predicted')
plt.ylabel('True')
for i in range(2):
    for j in range(2):
        plt.text(j, i, str(confusion_matrix_2x2[i, j]),␣
 ↪horizontalalignment='center', verticalalignment='center')

# Print the model's evaluation results
print('======= Neural Network Model ============')
print()
print("Model Accuracy:\n", accuracy)
print()
print("Confusion matrix 4x4:\n", confusion_matrix_4x4)
print()
print("Confusion matrix 2x2:\n", confusion_matrix_2x2)
print()
print("Classification report:\n", classification)
print()
```

```
Epoch 1/10
3994/3994 [==============================] - 10s 2ms/step - loss: 0.0416 -
```

```
accuracy: 0.9868
Epoch 2/10
3994/3994 [==============================] - 10s 2ms/step - loss: 0.0324 -
accuracy: 0.9879
Epoch 3/10
3994/3994 [==============================] - 10s 2ms/step - loss: 0.0317 -
accuracy: 0.9880
Epoch 4/10
3994/3994 [==============================] - 10s 2ms/step - loss: 0.0309 -
accuracy: 0.9879
Epoch 5/10
3994/3994 [==============================] - 10s 2ms/step - loss: 0.0304 -
accuracy: 0.9879
Epoch 6/10
3994/3994 [==============================] - 10s 2ms/step - loss: 0.0293 -
accuracy: 0.9881
Epoch 7/10
3994/3994 [==============================] - 10s 2ms/step - loss: 0.0278 -
accuracy: 0.9884
Epoch 8/10
3994/3994 [==============================] - 9s 2ms/step - loss: 0.0260 -
accuracy: 0.9890
Epoch 9/10
3994/3994 [==============================] - 10s 2ms/step - loss: 0.0244 -
accuracy: 0.9899
Epoch 10/10
3994/3994 [==============================] - 10s 2ms/step - loss: 0.0235 -
accuracy: 0.9900
999/999 [==============================] - 2s 2ms/step
======= Neural Network Model ============

Model Accuracy:
 0.9917368305737269

Confusion matrix 4x4:
 [[31390   109     2     1]
 [   12   288     0     0]
 [    1     0     1     0]
 [    4   135     0     6]]

Confusion matrix 2x2:
 [[31390   112]
 [   17   430]]

Classification report:
                           precision    recall  f1-score   support

                  BENIGN       1.00      1.00      1.00     31502
```

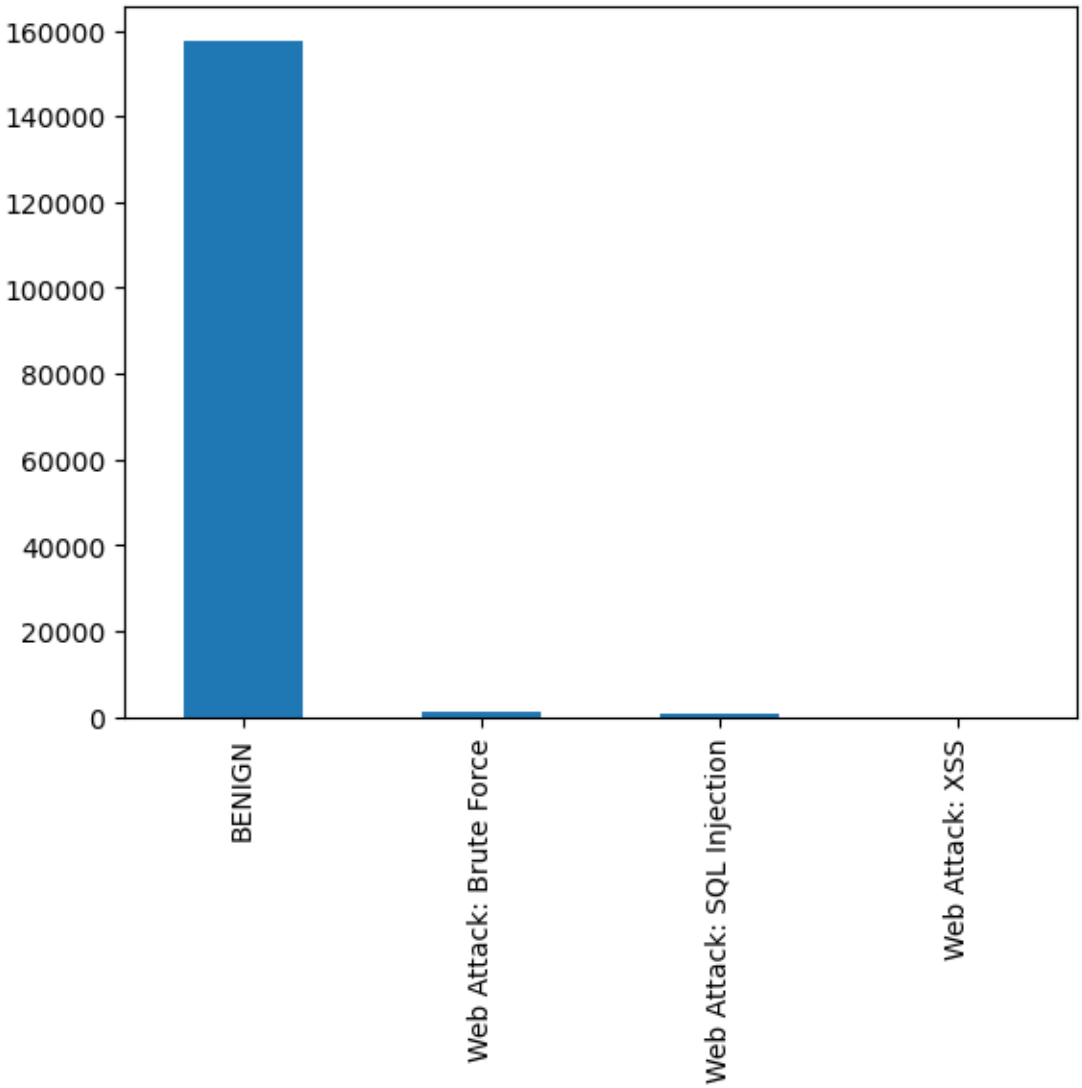
Web Attack: Brute Force	0.54	0.96	0.69	300
Web Attack: SQL Injection	0.33	0.50	0.40	2
Web Attack: XSS	0.86	0.04	0.08	145
accuracy			0.99	31949
macro avg	0.68	0.62	0.54	31949
weighted avg	0.99	0.99	0.99	31949





[22]:
```
print("Distribution of Attacks:")
df['Label'].value_counts().plot(kind='bar', xticks=np.arange(4),
                                tick_label=['BENIGN', 'Web Attack: Brute␣
 ↪Force', 'Web Attack: SQL Injection', 'Web Attack: XSS'])
plt.show()
```

```
Distribution of Attacks:
```



[25]:
```
# Create a DataFrame to store the evaluation metrics
evaluation_data = pd.DataFrame({
    'Model': ['Neural Network'],
    'Accuracy': [accuracy],
    'Precision': [precision],
    'Recall': [recall],
    'F1-score': [f1]
})

# Save the evaluation metrics to a CSV file
evaluation_data.to_csv('evaluation_results_NT.csv', index=False)
```

[26]:
```
print(evaluation_data)
```

```
              Model  Accuracy  Precision    Recall  F1-score
0  Neural Network  0.991737    0.99447  0.991737  0.990871
```

[ ]: