finalcode-1

August 29, 2024

1 Importing basic packages

[ ]:
```python
import pandas as pd
import numpy as np
import seaborn as sns
import matplotlib.pyplot as plt
```

2 Loading the data

We have taken the datset from https://www.unb.ca/cic/datasets/url-2016.html. Filtered Phsing and Benign data from it and formed and new dataset named Phising_Benign_dataset.

[ ]:
```python
data = pd.read_csv('/content/Phising_Benign_dataset.csv')
data.head()
```

[ ]:
```
   Querylength  domain_token_count  path_token_count  avgdomaintokenlen  \
0            0                   2                12                5.5
1            0                   3                12                5.0
2            2                   2                11                4.0
3            0                   2                 7                4.5
4           19                   2                10                6.0

   longdomaintokenlen  avgpathtokenlen  tld  charcompvowels  charcompace  \
0                   8         4.083334    2              15            7
1                  10         3.583333    3              12            8
2                   5         4.750000    2              16           11
3                   7         5.714286    2              15           10
4                   9         2.250000    2               9            5

   ldl_url  …  SymbolCount_FileName  SymbolCount_Extension  \
0        0  …                    -1                     -1
1        2  …                     1                      0
2        0  …                     2                      0
3        0  …                     0                      0
4        0  …                     5                      4

   SymbolCount_Afterpath  Entropy_URL  Entropy_Domain  Entropy_DirectoryName  \
```

```
0                      -1     0.676804       0.860529              -1.000000
1                      -1     0.715629       0.776796               0.693127
2                       1     0.677701       1.000000               0.677704
3                      -1     0.696067       0.879588               0.818007
4                       3     0.747202       0.833700               0.655459

   Entropy_Filename  Entropy_Extension  Entropy_Afterpath  URL_Type_obf_Type
0         -1.000000           -1.00000          -1.000000             benign
1          0.738315            1.00000          -1.000000             benign
2          0.916667            0.00000           0.898227             benign
3          0.753585            0.00000          -1.000000             benign
4          0.829535            0.83615           0.823008             benign

[5 rows x 80 columns]
```

3 Information about the dataset

[ ]:
```
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 15367 entries, 0 to 15366
Data columns (total 80 columns):
 #   Column                           Non-Null Count  Dtype
---  ------                           --------------  -----
 0   Querylength                      15367 non-null  int64
 1   domain_token_count               15367 non-null  int64
 2   path_token_count                 15367 non-null  int64
 3   avgdomaintokenlen                15367 non-null  float64
 4   longdomaintokenlen               15367 non-null  int64
 5   avgpathtokenlen                  15096 non-null  float64
 6   tld                              15367 non-null  int64
 7   charcompvowels                   15367 non-null  int64
 8   charcompace                      15367 non-null  int64
 9   ldl_url                          15367 non-null  int64
 10  ldl_domain                       15367 non-null  int64
 11  ldl_path                         15367 non-null  int64
 12  ldl_filename                     15367 non-null  int64
 13  ldl_getArg                       15367 non-null  int64
 14  dld_url                          15367 non-null  int64
 15  dld_domain                       15367 non-null  int64
 16  dld_path                         15367 non-null  int64
 17  dld_filename                     15367 non-null  int64
 18  dld_getArg                       15367 non-null  int64
 19  urlLen                           15367 non-null  int64
 20  domainlength                     15367 non-null  int64
 21  pathLength                       15367 non-null  int64
```

```
22  subDirLen                         15367 non-null  int64
23  fileNameLen                       15367 non-null  int64
24  this.fileExtLen                   15367 non-null  int64
25  ArgLen                            15367 non-null  int64
26  pathurlRatio                      15367 non-null  float64
27  ArgUrlRatio                       15367 non-null  float64
28  argDomanRatio                     15367 non-null  float64
29  domainUrlRatio                    15367 non-null  float64
30  pathDomainRatio                   15367 non-null  float64
31  argPathRatio                      15367 non-null  float64
32  executable                        15367 non-null  int64
33  isPortEighty                      15367 non-null  int64
34  NumberofDotsinURL                 15367 non-null  int64
35  ISIpAddressInDomainName           15367 non-null  int64
36  CharacterContinuityRate           15367 non-null  float64
37  LongestVariableValue              15367 non-null  int64
38  URL_DigitCount                    15367 non-null  int64
39  host_DigitCount                   15367 non-null  int64
40  Directory_DigitCount              15367 non-null  int64
41  File_name_DigitCount              15367 non-null  int64
42  Extension_DigitCount              15367 non-null  int64
43  Query_DigitCount                  15367 non-null  int64
44  URL_Letter_Count                  15367 non-null  int64
45  host_letter_count                 15367 non-null  int64
46  Directory_LetterCount             15367 non-null  int64
47  Filename_LetterCount              15367 non-null  int64
48  Extension_LetterCount             15367 non-null  int64
49  Query_LetterCount                 15367 non-null  int64
50  LongestPathTokenLength            15367 non-null  int64
51  Domain_LongestWordLength          15367 non-null  int64
52  Path_LongestWordLength            15367 non-null  int64
53  sub-Directory_LongestWordLength   15367 non-null  int64
54  Arguments_LongestWordLength       15367 non-null  int64
55  URL_sensitiveWord                 15367 non-null  int64
56  URLQueries_variable               15367 non-null  int64
57  spcharUrl                         15367 non-null  int64
58  delimeter_Domain                  15367 non-null  int64
59  delimeter_path                    15367 non-null  int64
60  delimeter_Count                   15367 non-null  int64
61  NumberRate_URL                    15367 non-null  float64
62  NumberRate_Domain                 15367 non-null  float64
63  NumberRate_DirectoryName          15358 non-null  float64
64  NumberRate_FileName               15358 non-null  float64
65  NumberRate_Extension              8012 non-null   float64
66  NumberRate_AfterPath              15364 non-null  float64
67  SymbolCount_URL                   15367 non-null  int64
68  SymbolCount_Domain                15367 non-null  int64
69  SymbolCount_Directoryname         15367 non-null  int64
```

```
 70  SymbolCount_FileName            15367 non-null  int64
 71  SymbolCount_Extension           15367 non-null  int64
 72  SymbolCount_Afterpath           15367 non-null  int64
 73  Entropy_URL                     15367 non-null  float64
 74  Entropy_Domain                  15367 non-null  float64
 75  Entropy_DirectoryName           13541 non-null  float64
 76  Entropy_Filename                15177 non-null  float64
 77  Entropy_Extension               15364 non-null  float64
 78  Entropy_Afterpath               15364 non-null  float64
 79  URL_Type_obf_Type               15367 non-null  object
dtypes: float64(21), int64(58), object(1)
memory usage: 9.4+ MB
```

4 Label Encoder (Scaler Operation)

Data that is categorical, such as objects or strings, may be turned into integers by the LabelEncoder. For each different kind, a different number is assigned to it.

[ ]:
```python
from sklearn.preprocessing import LabelEncoder
df = data.apply(LabelEncoder().fit_transform)
df.head()
```

[ ]:
```
   Querylength  domain_token_count  path_token_count  avgdomaintokenlen  \
0            0                   0                12                 45
1            0                   1                12                 36
2            2                   0                11                 20
3            0                   0                 7                 27
4           19                   0                10                 53

   longdomaintokenlen  avgpathtokenlen  tld  charcompvowels  charcompace  \
0                   6              219    0              15            7
1                   8              146    1              12            8
2                   3              316    0              16           11
3                   5              437    0              15           10
4                   7               18    0               9            5

   ldl_url  …  SymbolCount_FileName  SymbolCount_Extension  \
0        0  …                     0                      0
1        2  …                     2                      1
2        0  …                     3                      1
3        0  …                     1                      1
4        0  …                     6                      5

   SymbolCount_Afterpath  Entropy_URL  Entropy_Domain  Entropy_DirectoryName  \
0                      0         2829            1084                      0
1                      0         6500             671                    797
2                      2         2919            1168                    488
```

```
3                        0        4569          1116                     2906
4                        4        9600          1008                      228

   Entropy_Filename  Entropy_Extension  Entropy_Afterpath  URL_Type_obf_Type
0                 0                  0                  0                  0
1              2847                983                  0                  0
2              4703                  1               1089                  0
3              3180                  1                  0                  0
4              4289                784                899                  0

[5 rows x 80 columns]
```

Checking again if the datatypes of the features have changed to int or not.

[ ]:
```python
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 15367 entries, 0 to 15366
Data columns (total 80 columns):
 #   Column                           Non-Null Count  Dtype
---  ------                           --------------  -----
 0   Querylength                      15367 non-null  int64
 1   domain_token_count               15367 non-null  int64
 2   path_token_count                 15367 non-null  int64
 3   avgdomaintokenlen                15367 non-null  int64
 4   longdomaintokenlen               15367 non-null  int64
 5   avgpathtokenlen                  15367 non-null  int64
 6   tld                              15367 non-null  int64
 7   charcompvowels                   15367 non-null  int64
 8   charcompace                      15367 non-null  int64
 9   ldl_url                          15367 non-null  int64
 10  ldl_domain                       15367 non-null  int64
 11  ldl_path                         15367 non-null  int64
 12  ldl_filename                     15367 non-null  int64
 13  ldl_getArg                       15367 non-null  int64
 14  dld_url                          15367 non-null  int64
 15  dld_domain                       15367 non-null  int64
 16  dld_path                         15367 non-null  int64
 17  dld_filename                     15367 non-null  int64
 18  dld_getArg                       15367 non-null  int64
 19  urlLen                           15367 non-null  int64
 20  domainlength                     15367 non-null  int64
 21  pathLength                       15367 non-null  int64
 22  subDirLen                        15367 non-null  int64
 23  fileNameLen                      15367 non-null  int64
 24  this.fileExtLen                  15367 non-null  int64
 25  ArgLen                           15367 non-null  int64
 26  pathurlRatio                     15367 non-null  int64
```

```
27  ArgUrlRatio                      15367 non-null  int64
28  argDomanRatio                    15367 non-null  int64
29  domainUrlRatio                   15367 non-null  int64
30  pathDomainRatio                  15367 non-null  int64
31  argPathRatio                     15367 non-null  int64
32  executable                       15367 non-null  int64
33  isPortEighty                     15367 non-null  int64
34  NumberofDotsinURL                15367 non-null  int64
35  ISIpAddressInDomainName          15367 non-null  int64
36  CharacterContinuityRate          15367 non-null  int64
37  LongestVariableValue             15367 non-null  int64
38  URL_DigitCount                   15367 non-null  int64
39  host_DigitCount                  15367 non-null  int64
40  Directory_DigitCount             15367 non-null  int64
41  File_name_DigitCount             15367 non-null  int64
42  Extension_DigitCount             15367 non-null  int64
43  Query_DigitCount                 15367 non-null  int64
44  URL_Letter_Count                 15367 non-null  int64
45  host_letter_count                15367 non-null  int64
46  Directory_LetterCount            15367 non-null  int64
47  Filename_LetterCount             15367 non-null  int64
48  Extension_LetterCount            15367 non-null  int64
49  Query_LetterCount                15367 non-null  int64
50  LongestPathTokenLength           15367 non-null  int64
51  Domain_LongestWordLength         15367 non-null  int64
52  Path_LongestWordLength           15367 non-null  int64
53  sub-Directory_LongestWordLength  15367 non-null  int64
54  Arguments_LongestWordLength      15367 non-null  int64
55  URL_sensitiveWord                15367 non-null  int64
56  URLQueries_variable              15367 non-null  int64
57  spcharUrl                        15367 non-null  int64
58  delimeter_Domain                 15367 non-null  int64
59  delimeter_path                   15367 non-null  int64
60  delimeter_Count                  15367 non-null  int64
61  NumberRate_URL                   15367 non-null  int64
62  NumberRate_Domain                15367 non-null  int64
63  NumberRate_DirectoryName         15367 non-null  int64
64  NumberRate_FileName              15367 non-null  int64
65  NumberRate_Extension             15367 non-null  int64
66  NumberRate_AfterPath             15367 non-null  int64
67  SymbolCount_URL                  15367 non-null  int64
68  SymbolCount_Domain               15367 non-null  int64
69  SymbolCount_Directoryname        15367 non-null  int64
70  SymbolCount_FileName             15367 non-null  int64
71  SymbolCount_Extension            15367 non-null  int64
72  SymbolCount_Afterpath            15367 non-null  int64
73  Entropy_URL                      15367 non-null  int64
74  Entropy_Domain                   15367 non-null  int64
```

```
 75  Entropy_DirectoryName            15367 non-null  int64
 76  Entropy_Filename                 15367 non-null  int64
 77  Entropy_Extension                15367 non-null  int64
 78  Entropy_Afterpath                15367 non-null  int64
 79  URL_Type_obf_Type                15367 non-null  int64
dtypes: int64(80)
memory usage: 9.4 MB
```

We are not removing any duplicate values as we might lose the information of the data. As having duplicates won't effect our models. As we are doing classification models.

[ ]:
```
print(df.duplicated().sum())
```

```
544
```

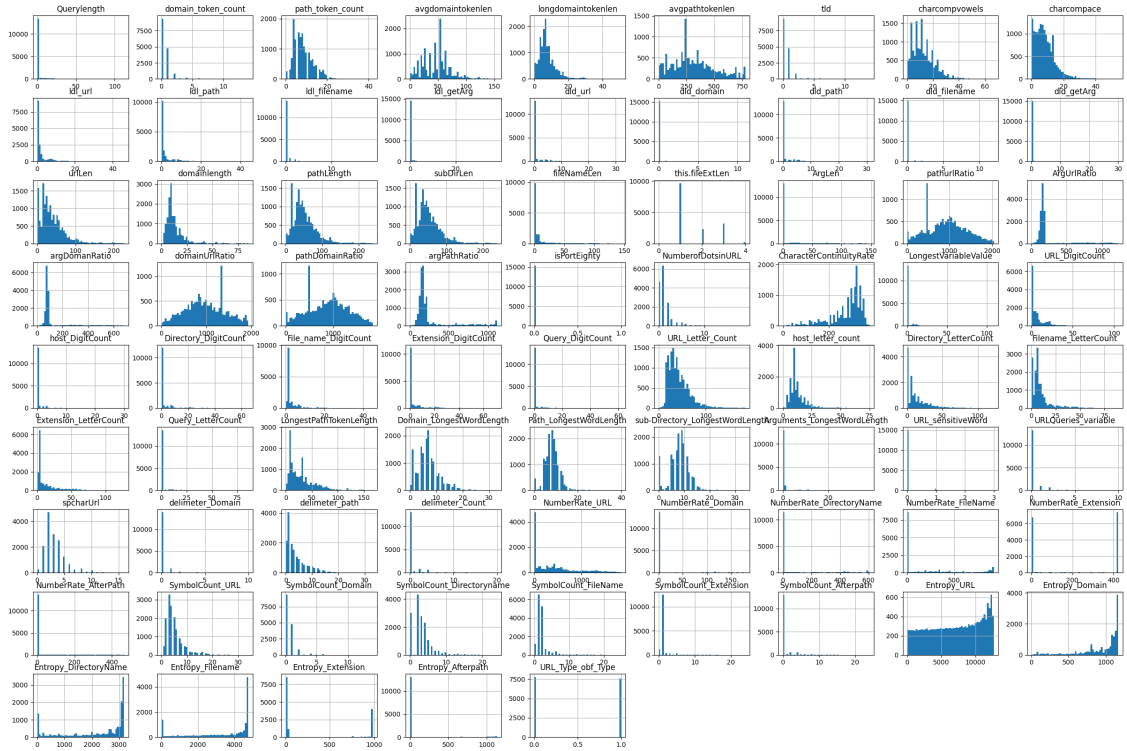
Dropping below columns as they have same values in the entire column. Which might effect the models.

[ ]:
```
df = df.drop(['executable','ISIpAddressInDomainName','ldl_domain'], axis=1)
```

5 Visualizing the data

Few plots and graphs are displayed to find how the data is distributed and the how features are related to each other.

[ ]:
```
#Plotting the data distribution
df.hist(bins = 50,figsize = (30,20))
plt.show()
```



6 Correlation of the data

[ ]:
```
correlation=df.corr()
correlation
```

[ ]:
```
                       Querylength  domain_token_count  path_token_count  \
Querylength               1.000000           -0.063481          0.234574
domain_token_count       -0.063481            1.000000         -0.270414
path_token_count          0.234574           -0.270414          1.000000
avgdomaintokenlen        -0.043416            0.053447         -0.255961
longdomaintokenlen       -0.067065            0.317163         -0.293741
…                          …                   …                  …
Entropy_DirectoryName     0.043913           -0.012705         -0.319198
Entropy_Filename         -0.114895            0.124783         -0.394685
Entropy_Extension        -0.016082           -0.111209         -0.118864
Entropy_Afterpath         0.352439           -0.094427          0.169601
URL_Type_obf_Type        -0.065766            0.495312         -0.454181

                       avgdomaintokenlen  longdomaintokenlen  avgpathtokenlen  \
Querylength                    -0.043416           -0.067065         0.037340
domain_token_count              0.053447            0.317163         0.079354
path_token_count               -0.255961           -0.293741        -0.173205
```

avgdomaintokenlen	1.000000	0.887047	0.108265
longdomaintokenlen	0.887047	1.000000	0.153512
…	…	…	…
Entropy_DirectoryName	0.028962	-0.002107	-0.112258
Entropy_Filename	0.007659	0.030843	-0.186709
Entropy_Extension	-0.030040	-0.083779	-0.239924
Entropy_Afterpath	-0.135240	-0.153507	-0.181262
URL_Type_obf_Type	0.286378	0.415452	0.086499

	tld	charcompvowels	charcompace	ldl_url	… \
Querylength	-0.063481	0.278098	0.384460	0.434302	…
domain_token_count	1.000000	-0.194231	-0.129430	0.151788	…
path_token_count	-0.270414	0.793478	0.684128	0.019554	…
avgdomaintokenlen	0.053447	-0.216402	-0.147098	0.090549	…
longdomaintokenlen	0.317163	-0.225257	-0.141619	0.140814	…
…	…	…	…	…	…
Entropy_DirectoryName	-0.012705	-0.270321	-0.267258	-0.024532	…
Entropy_Filename	0.124783	-0.384922	-0.363172	-0.122638	…
Entropy_Extension	-0.111209	-0.216721	-0.233158	-0.116202	…
Entropy_Afterpath	-0.094427	0.081264	0.077321	0.007288	…
URL_Type_obf_Type	0.495312	-0.364946	-0.226098	0.251548	…

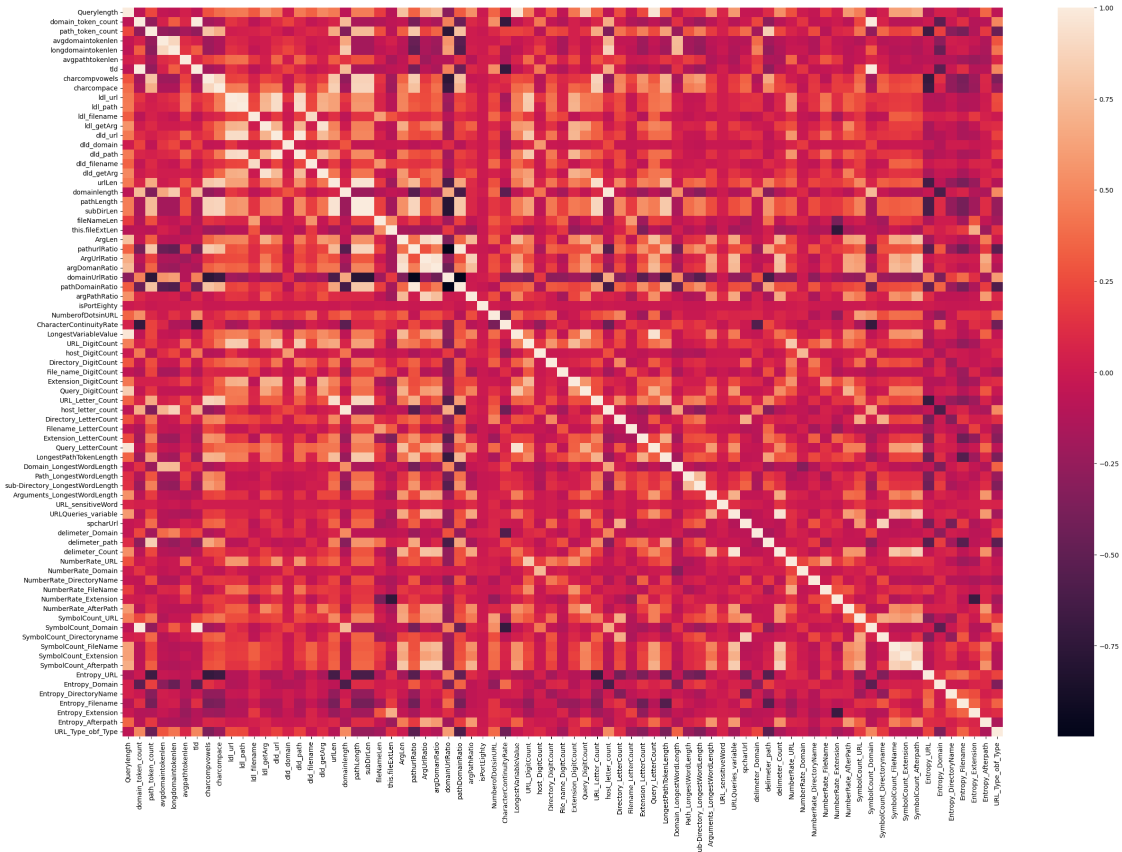
	SymbolCount_FileName	SymbolCount_Extension \
Querylength	0.624241	0.616856
domain_token_count	-0.088291	-0.087283
path_token_count	0.211475	0.217613
avgdomaintokenlen	-0.078032	-0.066668
longdomaintokenlen	-0.109144	-0.095082
…	…	…
Entropy_DirectoryName	0.212704	0.165671
Entropy_Filename	0.057884	-0.027774
Entropy_Extension	0.212504	0.107704
Entropy_Afterpath	0.468516	0.347926
URL_Type_obf_Type	-0.075428	-0.112313

	SymbolCount_Afterpath	Entropy_URL	Entropy_Domain \
Querylength	0.677300	-0.126299	0.046519
domain_token_count	-0.076923	-0.003770	-0.515622
path_token_count	0.323497	-0.663022	0.197231
avgdomaintokenlen	-0.112602	-0.025991	-0.292712
longdomaintokenlen	-0.131689	-0.046429	-0.467609
…	…	…	…
Entropy_DirectoryName	0.052446	0.338693	0.002008
Entropy_Filename	-0.046087	0.392061	-0.002891
Entropy_Extension	-0.010142	0.208021	0.068594
Entropy_Afterpath	0.552517	0.105404	0.095044
URL_Type_obf_Type	-0.115198	0.212720	-0.354974

```
                       Entropy_DirectoryName  Entropy_Filename  \
Querylength                         0.043913         -0.114895
domain_token_count                 -0.012705          0.124783
path_token_count                   -0.319198         -0.394685
avgdomaintokenlen                   0.028962          0.007659
longdomaintokenlen                 -0.002107          0.030843
…                                        …               …
Entropy_DirectoryName               1.000000          0.319302
Entropy_Filename                    0.319302          1.000000
Entropy_Extension                   0.257961          0.351448
Entropy_Afterpath                   0.036234          0.121909
URL_Type_obf_Type                   0.079970          0.337844

                       Entropy_Extension  Entropy_Afterpath  URL_Type_obf_Type
Querylength                    -0.016082           0.352439          -0.065766
domain_token_count             -0.111209          -0.094427           0.495312
path_token_count               -0.118864           0.169601          -0.454181
avgdomaintokenlen              -0.030040          -0.135240           0.286378
longdomaintokenlen             -0.083779          -0.153507           0.415452
…                                    …                 …                 …
Entropy_DirectoryName           0.257961           0.036234           0.079970
Entropy_Filename                0.351448           0.121909           0.337844
Entropy_Extension               1.000000           0.075549           0.112423
Entropy_Afterpath               0.075549           1.000000          -0.144868
URL_Type_obf_Type               0.112423          -0.144868           1.000000

[77 rows x 77 columns]
```

7 Heatmap

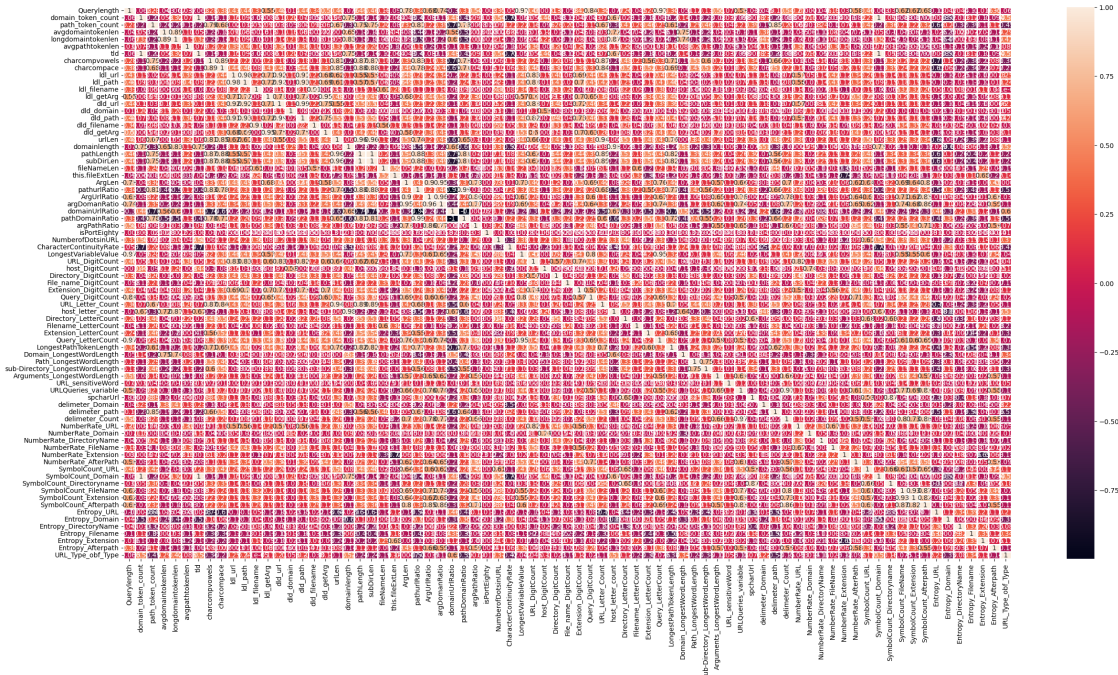
[ ]:
```
plt.figure(figsize=(30,20))
sns.heatmap(df.corr())
plt.show()
```



Plotting another heatmap to clearly view the data.

[ ]:
```python
import seaborn as sns
import matplotlib.pyplot as plt

plt.subplots(figsize=(30,15))
map1=sns.heatmap(correlation, annot=True, linewidth=1) #cmap='coolwarm')
map1
```

[ ]: <Axes: >



[ ]:
```python
print(df.columns)
```

```
Index(['Querylength', 'domain_token_count', 'path_token_count',
       'avgdomaintokenlen', 'longdomaintokenlen', 'avgpathtokenlen', 'tld',
       'charcompvowels', 'charcompace', 'ldl_url', 'ldl_path', 'ldl_filename',
       'ldl_getArg', 'dld_url', 'dld_domain', 'dld_path', 'dld_filename',
       'dld_getArg', 'urlLen', 'domainlength', 'pathLength', 'subDirLen',
       'fileNameLen', 'this.fileExtLen', 'ArgLen', 'pathurlRatio',
       'ArgUrlRatio', 'argDomanRatio', 'domainUrlRatio', 'pathDomainRatio',
       'argPathRatio', 'isPortEighty', 'NumberofDotsinURL',
       'CharacterContinuityRate', 'LongestVariableValue', 'URL_DigitCount',
       'host_DigitCount', 'Directory_DigitCount', 'File_name_DigitCount',
       'Extension_DigitCount', 'Query_DigitCount', 'URL_Letter_Count',
       'host_letter_count', 'Directory_LetterCount', 'Filename_LetterCount',
       'Extension_LetterCount', 'Query_LetterCount', 'LongestPathTokenLength',
       'Domain_LongestWordLength', 'Path_LongestWordLength',
       'sub-Directory_LongestWordLength', 'Arguments_LongestWordLength',
       'URL_sensitiveWord', 'URLQueries_variable', 'spcharUrl',
       'delimeter_Domain', 'delimeter_path', 'delimeter_Count',
       'NumberRate_URL', 'NumberRate_Domain', 'NumberRate_DirectoryName',
       'NumberRate_FileName', 'NumberRate_Extension', 'NumberRate_AfterPath',
       'SymbolCount_URL', 'SymbolCount_Domain', 'SymbolCount_Directoryname',
       'SymbolCount_FileName', 'SymbolCount_Extension',
       'SymbolCount_Afterpath', 'Entropy_URL', 'Entropy_Domain',
       'Entropy_DirectoryName', 'Entropy_Filename', 'Entropy_Extension',
```

```
       'Entropy_Afterpath', 'URL_Type_obf_Type'],
      dtype='object')
```

[ ]:
```
# Sepratating & assigning features and target columns to X & y
y = df['URL_Type_obf_Type']
X = df.drop('URL_Type_obf_Type',axis=1)
X.shape, y.shape
```

[ ]:
```
((15367, 76), (15367,))
```

[ ]:
```
# Splitting the dataset into train and test sets: 80-20 split
from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test = train_test_split(X, y,
                                                    test_size = 0.2,
 ↪random_state = 12)
X_train.shape, X_test.shape
```

[ ]:
```
((12293, 76), (3074, 76))
```

[ ]:
```
#importing packages
from sklearn.metrics import accuracy_score
```

8 Applying models

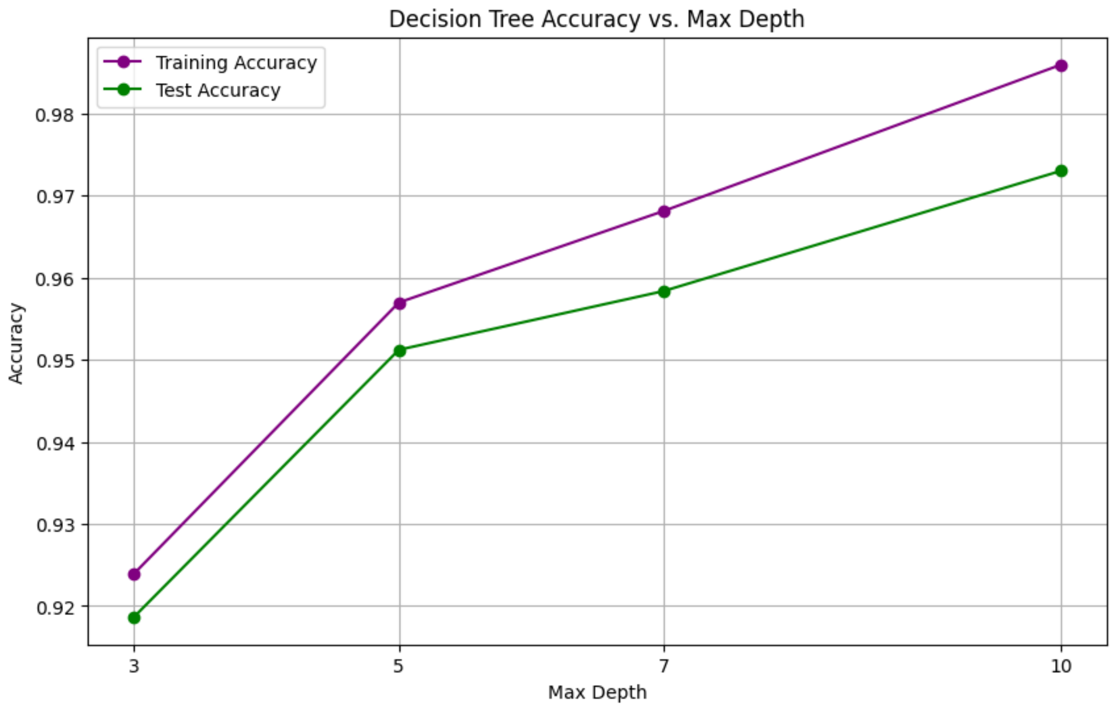
9 Decision tree

[ ]:
```
# Creating holders to store the model performance results
ML_Model = []
acc_train = []
acc_test = []

#function to call for storing the results
def storeResults(model, a,b):
  ML_Model.append(model)
  acc_train.append(round(a, 3))
  acc_test.append(round(b, 3))
```

10 Decision tree with max depth 3, 5, 7, 10

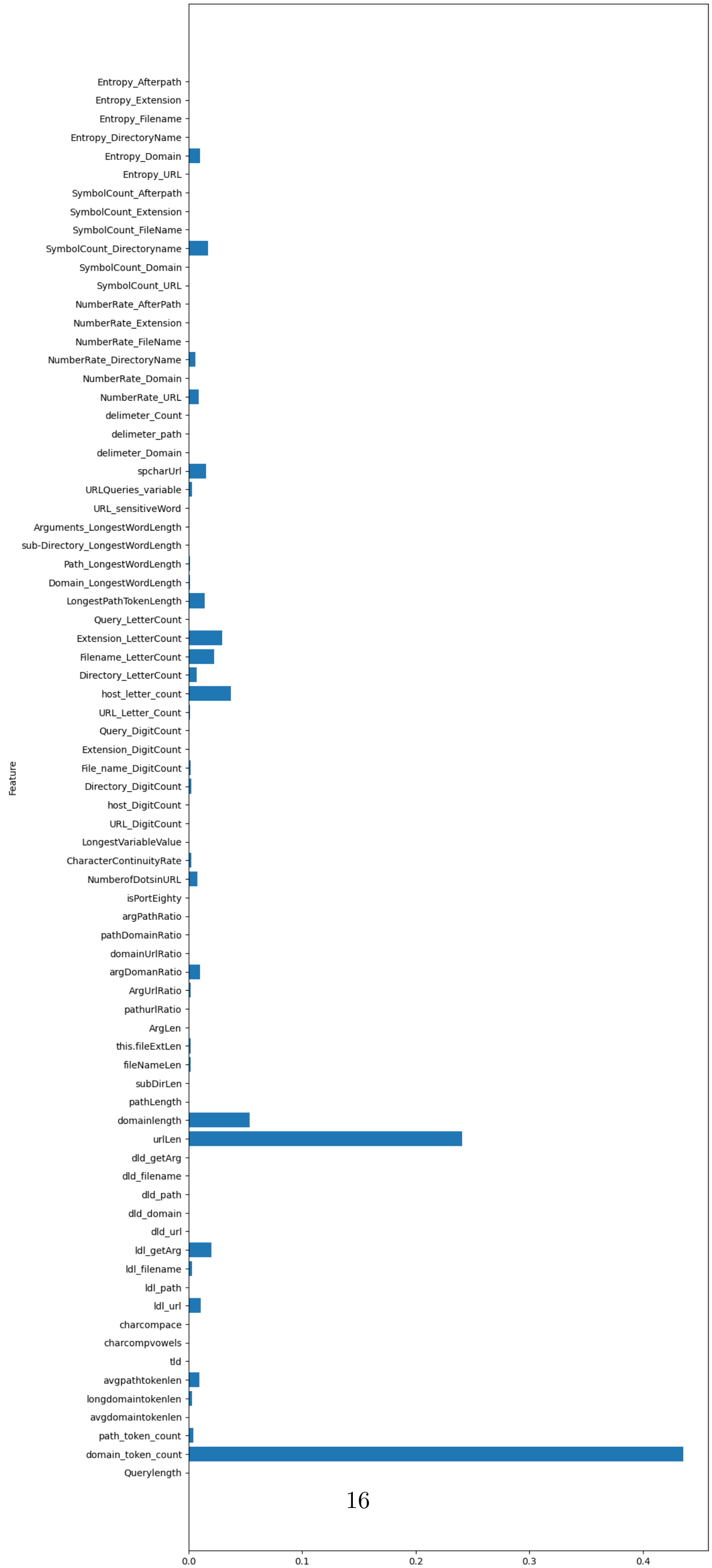
[ ]:
```
import matplotlib.pyplot as plt
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import accuracy_score

# Lists to store accuracies
```

```
train_accuracies = []
test_accuracies = []
depths = [3, 5, 7, 10]

# Loop through each depth
for depth in depths:
    # Instantiate and train the model
    tree = DecisionTreeClassifier(max_depth=depth)
    tree.fit(X_train, y_train)

    # Predict for both train and test sets
    y_train_pred = tree.predict(X_train)
    y_test_pred = tree.predict(X_test)

    # Calculate accuracies
    acc_train_tree = accuracy_score(y_train, y_train_pred)
    acc_test_tree = accuracy_score(y_test, y_test_pred)

    # Append the accuracies to the lists
    train_accuracies.append(acc_train_tree)
    test_accuracies.append(acc_test_tree)

# Plotting the results
plt.figure(figsize=(10, 6))
plt.plot(depths, train_accuracies, label='Training Accuracy', marker='o',␣
 ↪color='purple')
plt.plot(depths, test_accuracies, label='Test Accuracy', marker='o',␣
 ↪color='green')
plt.title('Decision Tree Accuracy vs. Max Depth')
plt.xlabel('Max Depth')
plt.ylabel('Accuracy')
plt.xticks(depths)
plt.legend()
plt.grid(True)
plt.show()
```



In the above plot we can see that the accuracy is increasing as we are going more deep into the decision tree.

[ ]:
```
#checking the feature improtance in the model
plt.figure(figsize=(10,30))
n_features = X_train.shape[1]
plt.barh(range(n_features), tree.feature_importances_, align='center')
plt.yticks(np.arange(n_features), X_train.columns)
plt.xlabel("Feature importance")
plt.ylabel("Feature")
plt.show()
```


Entropy_Afterpath
Entropy_Extension
Entropy_Filename
Entropy_DirectoryName
Entropy_Domain
Entropy_URL
SymbolCount_Afterpath
SymbolCount_Extension
SymbolCount_FileName
SymbolCount_Directoryname
SymbolCount_Domain
SymbolCount_URL
NumberRate_AfterPath
NumberRate_Extension
NumberRate_FileName
NumberRate_DirectoryName
NumberRate_Domain
NumberRate_URL
delimeter_Count
delimeter_path
delimeter_Domain
spcharUrl
URLQueries_variable
URL_sensitiveWord
Arguments_LongestWordLength
sub-Directory_LongestWordLength
Path_LongestWordLength
Domain_LongestWordLength
LongestPathTokenLength
Query_LetterCount
Extension_LetterCount
Filename_LetterCount
Directory_LetterCount
host_letter_count
URL_Letter_Count
Query_DigitCount
Extension_DigitCount
File_name_DigitCount
Directory_DigitCount
host_DigitCount
URL_DigitCount
LongestVariableValue
CharacterContinuityRate
NumberofDotsinURL
isPortEighty
argPathRatio
pathDomainRatio
domainUrlRatio
argDomanRatio
ArgUrlRatio
pathurlRatio
ArgLen
this.fileExtLen
fileNameLen
subDirLen
pathLength
domainlength
urlLen
dld_getArg
dld_filename
dld_path
dld_domain
dld_url
ldl_getArg
ldl_filename
ldl_path
ldl_url
charcompace
charcompvowels
tld
avgpathtokenlen
longdomaintokenlen
avgdomaintokenlen
path_token_count
domain_token_count
Querylength
Feature
0.0
0.1
0.2
0.3
0.4
Feature importance

[ ]:
```
#storing the results. The below mentioned order of parameter passing is␣
↪important.
#Caution: Execute only once to avoid duplications.
storeResults('Decision Tree', acc_train_tree, acc_test_tree)
```

11 Applying Decision tree removing features which are not useful.

[ ]:
```
ydt = df['URL_Type_obf_Type']
Xdt = df.drop(['URL_Type_obf_Type','Querylength', 'domain_token_count',␣
↪'path_token_count',
        'avgdomaintokenlen', 'longdomaintokenlen', 'avgpathtokenlen',
        'charcompvowels', 'charcompace', 'ldl_path', 'dld_url', 'dld_domain',␣
↪'dld_path',
        'dld_filename', 'dld_getArg', 'pathLength',
        'subDirLen', 'fileNameLen', 'this.fileExtLen', 'ArgLen', 'pathurlRatio',
        'ArgUrlRatio', 'argDomanRatio', 'domainUrlRatio', 'pathDomainRatio',
        'argPathRatio', 'isPortEighty', 'NumberofDotsinURL',
        'CharacterContinuityRate', 'LongestVariableValue', 'URL_DigitCount',
        'host_DigitCount', 'Directory_DigitCount', 'File_name_DigitCount',
        'Extension_DigitCount', 'Query_DigitCount', 'URL_Letter_Count',␣
↪'Directory_LetterCount', 'Query_LetterCount', 'LongestPathTokenLength',
        'Domain_LongestWordLength', 'Path_LongestWordLength',
        'sub-Directory_LongestWordLength', 'Arguments_LongestWordLength',
        'URL_sensitiveWord',
        'delimeter_Domain', 'delimeter_path', 'delimeter_Count',
        'NumberRate_URL', 'NumberRate_Domain',
        'NumberRate_FileName', 'NumberRate_Extension', 'NumberRate_AfterPath',
        'SymbolCount_URL', 'SymbolCount_Domain',
        'SymbolCount_FileName', 'SymbolCount_Extension',
        'SymbolCount_Afterpath', 'Entropy_URL',
        'Entropy_DirectoryName', 'Entropy_Filename', 'Entropy_Extension',
        'Entropy_Afterpath',],axis=1)
Xdt.shape, ydt.shape
```

[ ]:
```
((15367, 14), (15367,))
```

[ ]:
```
# Splitting the dataset into train and test sets: 80-20 split
from sklearn.model_selection import train_test_split

Xdt_train, Xdt_test, ydt_train, ydt_test = train_test_split(Xdt, ydt,
                                                            test_size = 0.2,␣
↪random_state = 12)
Xdt_train.shape, Xdt_test.shape
```

```
[ ]: ((12293, 14), (3074, 14))
```

```
[ ]: # Decision Tree model
     from sklearn.tree import DecisionTreeClassifier

     # instantiate the model
     treedt = DecisionTreeClassifier(max_depth = 5)
     # fit the model
     tree.fit(Xdt_train, ydt_train)
```

```
[ ]: DecisionTreeClassifier(max_depth=10)
```

```
[ ]: #predicting the target value from the model for the samples
     ydt_test_tree = tree.predict(Xdt_test)
     ydt_train_tree = tree.predict(Xdt_train)
```

```
[ ]: #computing the accuracy of the model performance
     dtacc_train_tree = accuracy_score(ydt_train,ydt_train_tree)
     dtacc_test_tree = accuracy_score(ydt_test,ydt_test_tree)

     print("Decision Tree: Accuracy on training Data: {:.3f}".
      ↪format(dtacc_train_tree))
     print("Decision Tree: Accuracy on test Data: {:.3f}".format(dtacc_test_tree))
```

```
Decision Tree: Accuracy on training Data: 0.978
Decision Tree: Accuracy on test Data: 0.965
```

12 The difference in accuracy when removing unimportant features and applying the models is minimal. The change in accuracy is only 0.01, which is negligible. Hence, we will retain all features.

13 Random forest

```
[ ]: # Random Forest model
     from sklearn.ensemble import RandomForestClassifier

     # instantiate the model
     forest = RandomForestClassifier(max_depth=5)

     # fit the model
     forest.fit(X_train, y_train)
```

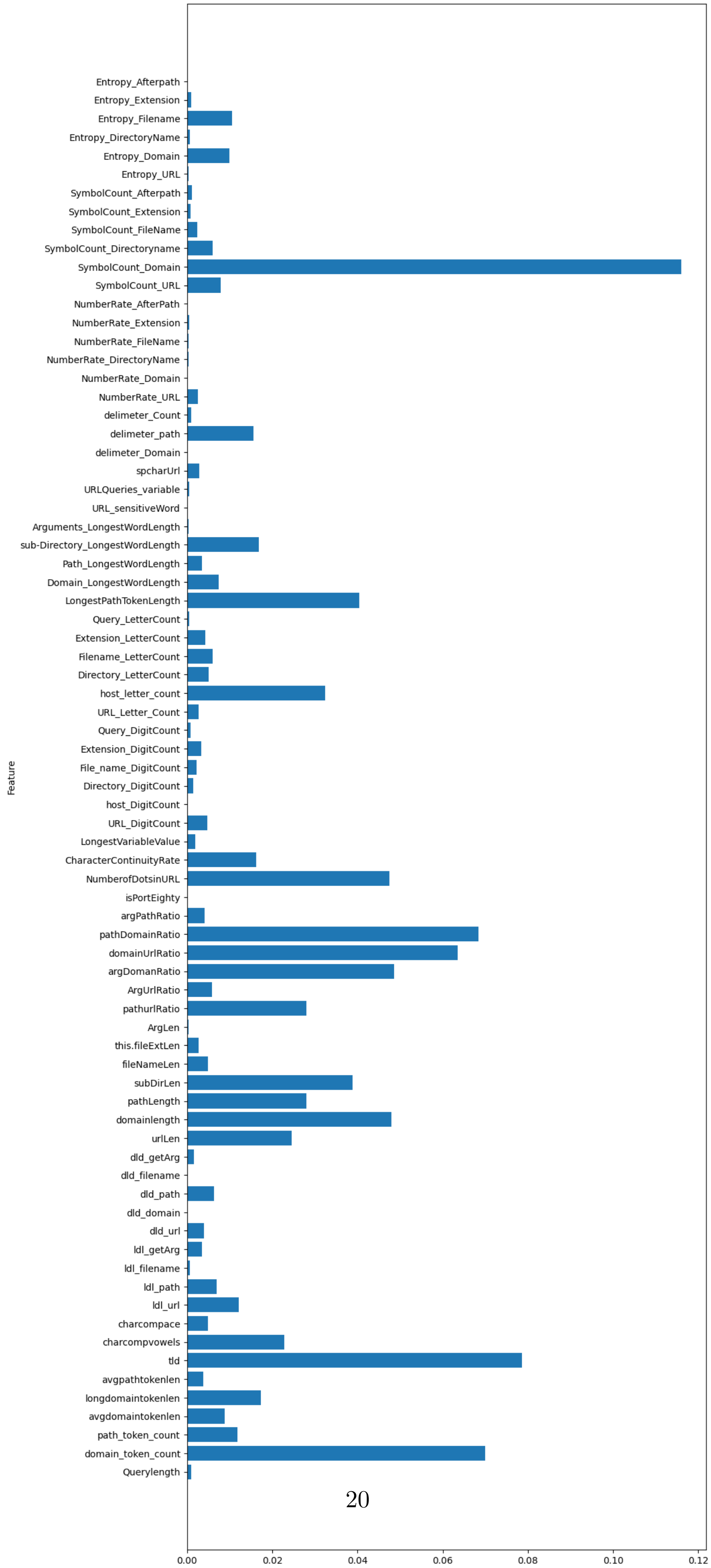
```
[ ]: RandomForestClassifier(max_depth=5)
```

```
[ ]: #predicting the target value from the model for the samples
y_test_forest = forest.predict(X_test)
y_train_forest = forest.predict(X_train)
```

```
[ ]: #computing the accuracy of the model performance
acc_train_forest = accuracy_score(y_train,y_train_forest)
acc_test_forest = accuracy_score(y_test,y_test_forest)

print("Random forest: Accuracy on training Data: {:.3f}".
 ↪format(acc_train_forest))
print("Random forest: Accuracy on test Data: {:.3f}".format(acc_test_forest))
```

```
Random forest: Accuracy on training Data: 0.958
Random forest: Accuracy on test Data: 0.952
```

```
[ ]: #checking the feature improtance in the model
plt.figure(figsize=(10,30))
n_features = X_train.shape[1]
plt.barh(range(n_features), forest.feature_importances_, align='center')
plt.yticks(np.arange(n_features), X_train.columns)
plt.xlabel("Feature importance")
plt.ylabel("Feature")
plt.show()
```


Entropy_Afterpath
Entropy_Extension
Entropy_Filename
Entropy_DirectoryName
Entropy_Domain
Entropy_URL
SymbolCount_Afterpath
SymbolCount_Extension
SymbolCount_FileName
SymbolCount_Directoryname
SymbolCount_Domain
SymbolCount_URL
NumberRate_AfterPath
NumberRate_Extension
NumberRate_FileName
NumberRate_DirectoryName
NumberRate_Domain
NumberRate_URL
delimeter_Count
delimeter_path
delimeter_Domain
spcharUrl
URLQueries_variable
URL_sensitiveWord
Arguments_LongestWordLength
sub-Directory_LongestWordLength
Path_LongestWordLength
Domain_LongestWordLength
LongestPathTokenLength
Query_LetterCount
Extension_LetterCount
Filename_LetterCount
Directory_LetterCount
host_letter_count
URL_Letter_Count
Query_DigitCount
Extension_DigitCount
File_name_DigitCount
Directory_DigitCount
host_DigitCount
URL_DigitCount
LongestVariableValue
CharacterContinuityRate
NumberofDotsinURL
isPortEighty
argPathRatio
pathDomainRatio
domainUrlRatio
argDomanRatio
ArgUrlRatio
pathurlRatio
ArgLen
this.fileExtLen
fileNameLen
subDirLen
pathLength
domainlength
urlLen
dld_getArg
dld_filename
dld_path
dld_domain
dld_url
ldl_getArg
ldl_filename
ldl_path
ldl_url
charcompace
charcompvowels
tld
avgpathtokenlen
longdomaintokenlen
avgdomaintokenlen
path_token_count
domain_token_count
Querylength
Feature
0.00
0.02
0.04
0.06
0.08
0.10
0.12
Feature importance

```
[ ]: #storing the results. The below mentioned order of parameter passing is␣
      ↪important.
     #Caution: Execute only once to avoid duplications.
     storeResults('Random Forest', acc_train_forest, acc_test_forest)
```

14 XGBoost Classifier

```
[ ]: #XGBoost Classification model
     from xgboost import XGBClassifier

     # instantiate the model
     xgb = XGBClassifier(learning_rate=0.4,max_depth=7)
     #fit the model
     xgb.fit(X_train, y_train)
```

```
[ ]: XGBClassifier(base_score=None, booster=None, callbacks=None,
                   colsample_bylevel=None, colsample_bynode=None,
                   colsample_bytree=None, device=None, early_stopping_rounds=None,
                   enable_categorical=False, eval_metric=None, feature_types=None,
                   gamma=None, grow_policy=None, importance_type=None,
                   interaction_constraints=None, learning_rate=0.4, max_bin=None,
                   max_cat_threshold=None, max_cat_to_onehot=None,
                   max_delta_step=None, max_depth=7, max_leaves=None,
                   min_child_weight=None, missing=nan, monotone_constraints=None,
                   multi_strategy=None, n_estimators=None, n_jobs=None,
                   num_parallel_tree=None, random_state=None, …)
```

```
[ ]: #predicting the target value from the model for the samples
     y_test_xgb = xgb.predict(X_test)
     y_train_xgb = xgb.predict(X_train)
```

```
[ ]: #computing the accuracy of the model performance
     acc_train_xgb = accuracy_score(y_train,y_train_xgb)
     acc_test_xgb = accuracy_score(y_test,y_test_xgb)

     print("XGBoost: Accuracy on training Data: {:.3f}".format(acc_train_xgb))
     print("XGBoost : Accuracy on test Data: {:.3f}".format(acc_test_xgb))
```

```
XGBoost: Accuracy on training Data: 1.000
XGBoost : Accuracy on test Data: 0.987
```

```
[ ]: #storing the results. The below mentioned order of parameter passing is␣
      ↪important.
     #Caution: Execute only once to avoid duplications.
```

```
storeResults('XGBoost', acc_train_xgb, acc_test_xgb)
```

15 Support Vector Machine

[ ]:
```
from sklearn.svm import SVC # import the SVC class from sklearn.svm

# instantiate the model with adjusted parameters
svm = SVC(kernel='linear', max_iter=1000)  # limiting the number of iterations

# fit the model
svm.fit(X_train, y_train)
```

```
/usr/local/lib/python3.10/dist-packages/sklearn/svm/_base.py:297:
ConvergenceWarning: Solver terminated early (max_iter=1000).  Consider pre-
processing your data with StandardScaler or MinMaxScaler.
  warnings.warn(
```

[ ]:
```
SVC(kernel='linear', max_iter=1000)
```

[ ]:
```
#predicting the target value from the model for the samples
y_test_svm = svm.predict(X_test)
y_train_svm = svm.predict(X_train)
```

[ ]:
```
#computing the accuracy of the model performance
acc_train_svm = accuracy_score(y_train,y_train_svm)
acc_test_svm = accuracy_score(y_test,y_test_svm)

print("SVM: Accuracy on training Data: {:.3f}".format(acc_train_svm))
print("SVM : Accuracy on test Data: {:.3f}".format(acc_test_svm))
```

```
SVM: Accuracy on training Data: 0.575
SVM : Accuracy on test Data: 0.569
```

[ ]:
```
#storing the results. The below mentioned order of parameter passing is␣
↪important.
storeResults('SVM', acc_train_svm, acc_test_svm)
```

16 Ensembelled model

We have used Decision tree, Random forest, XGBoost and SVM for ensembelled model.

[ ]:
```
!pip install scikit-learn
```

```
Requirement already satisfied: scikit-learn in /usr/local/lib/python3.10/dist-
packages (1.3.2)
Requirement already satisfied: numpy<2.0,>=1.17.3 in
```

```
/usr/local/lib/python3.10/dist-packages (from scikit-learn) (1.26.4)
Requirement already satisfied: scipy>=1.5.0 in /usr/local/lib/python3.10/dist-
packages (from scikit-learn) (1.13.1)
Requirement already satisfied: joblib>=1.1.1 in /usr/local/lib/python3.10/dist-
packages (from scikit-learn) (1.4.2)
Requirement already satisfied: threadpoolctl>=2.0.0 in
/usr/local/lib/python3.10/dist-packages (from scikit-learn) (3.5.0)
```

[ ]:
```python
from sklearn.ensemble import VotingClassifier

# Assuming X and y are your features and target variable
X = df.drop(['URL_Type_obf_Type'], axis=1)
y = df['URL_Type_obf_Type']

# Splitting the data into training and testing sets
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2,␣
↪random_state=42)

# Defining the base models
model1 = tree
model2 = forest
model3 = xgb
model4 = svm

# Creating the Voting Classifier
ensemble_model = VotingClassifier(estimators=[
    ('dt', model1), ('rf', model2),('xb',model3),('sv',model4)],
    voting='hard')

# Training the ensemble model

ensemble_model.fit(X_train, y_train)

y_test_ensemble = ensemble_model.predict(X_test)
y_train_ensemble = ensemble_model.predict(X_train)
```

```
/usr/local/lib/python3.10/dist-packages/sklearn/svm/_base.py:297:
ConvergenceWarning: Solver terminated early (max_iter=1000).  Consider pre-
processing your data with StandardScaler or MinMaxScaler.
  warnings.warn(
```

[ ]:
```python
#computing the accuracy of the model performance
acc_train_ensem = accuracy_score(y_train,y_train_ensemble)
acc_test_ensem = accuracy_score(y_test,y_test_ensemble)

print("Ensem: Accuracy on training Data: {:.3f}".format(acc_train_ensem))
print("Ensem : Accuracy on test Data: {:.3f}".format(acc_test_ensem))
```

```
Ensem: Accuracy on training Data: 0.979
Ensem : Accuracy on test Data: 0.970
```

[ ]:
```
#storing the results. The below mentioned order of parameter passing is␣
↪important.
#Caution: Execute only once to avoid duplications.
storeResults('Ensem', acc_train_ensem, acc_test_ensem)
```

17 LSTM(Long Short-Term Memory)

[ ]:
```
import pandas as pd
import numpy as np
import tensorflow as tf
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import LSTM, Dense
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler
from sklearn.metrics import accuracy_score
import matplotlib.pyplot as plt
```

[ ]:
```
# Scaling the data
scaler = StandardScaler()
X_train_scaled = scaler.fit_transform(X_train)
X_test_scaled = scaler.transform(X_test)
```

[ ]:
```
# Reshape for LSTM (assuming time_steps = 1 for simplicity)
time_steps = 1  # Example time step, adjust as needed
X_train_scaled = X_train_scaled.reshape((X_train_scaled.shape[0], time_steps,␣
↪X_train_scaled.shape[1]))
X_test_scaled = X_test_scaled.reshape((X_test_scaled.shape[0], time_steps,␣
↪X_test_scaled.shape[1]))
```

[ ]:
```
# Build LSTM model
model = Sequential()
model.add(LSTM(50, activation='relu', input_shape=(time_steps, X_train_scaled.
↪shape[2])))
model.add(Dense(1, activation='sigmoid'))

model.compile(optimizer='adam', loss='binary_crossentropy',␣
↪metrics=['accuracy'])
```

```
/usr/local/lib/python3.10/dist-packages/keras/src/layers/rnn/rnn.py:204:
UserWarning: Do not pass an `input_shape`/`input_dim` argument to a layer. When
using Sequential models, prefer using an `Input(shape)` object as the first
layer in the model instead.
  super().__init__(**kwargs)
```

[ ]:
```python
# Train the model
history = model.fit(X_train_scaled, y_train, epochs=10, batch_size=32,␣
↪validation_split=0.2)
```

```
Epoch 1/10
308/308              13s 20ms/step -
accuracy: 0.8758 - loss: 0.3498 - val_accuracy: 0.9484 - val_loss: 0.1241
Epoch 2/10
308/308              7s 10ms/step -
accuracy: 0.9656 - loss: 0.1005 - val_accuracy: 0.9581 - val_loss: 0.1042
Epoch 3/10
308/308              2s 7ms/step -
accuracy: 0.9708 - loss: 0.0832 - val_accuracy: 0.9630 - val_loss: 0.0958
Epoch 4/10
308/308              2s 6ms/step -
accuracy: 0.9728 - loss: 0.0766 - val_accuracy: 0.9671 - val_loss: 0.0893
Epoch 5/10
308/308              2s 7ms/step -
accuracy: 0.9768 - loss: 0.0705 - val_accuracy: 0.9650 - val_loss: 0.0902
Epoch 6/10
308/308              2s 6ms/step -
accuracy: 0.9804 - loss: 0.0636 - val_accuracy: 0.9695 - val_loss: 0.0844
Epoch 7/10
308/308              2s 5ms/step -
accuracy: 0.9781 - loss: 0.0604 - val_accuracy: 0.9695 - val_loss: 0.0815
Epoch 8/10
308/308              1s 3ms/step -
accuracy: 0.9820 - loss: 0.0550 - val_accuracy: 0.9695 - val_loss: 0.0798
Epoch 9/10
308/308              1s 3ms/step -
accuracy: 0.9822 - loss: 0.0498 - val_accuracy: 0.9707 - val_loss: 0.0782
Epoch 10/10
308/308              1s 3ms/step -
accuracy: 0.9830 - loss: 0.0503 - val_accuracy: 0.9703 - val_loss: 0.0752
```

[ ]:
```python
# Predict and evaluate
y_pred_lstm = model.predict(X_test_scaled)
y_pred_lstm_classes = (y_pred_lstm > 0.5).astype(int)

accuracy_lstm = accuracy_score(y_test, y_pred_lstm_classes)
print(f'LSTM Model Accuracy: {accuracy_lstm:.2f}')
```

```
97/97              1s 3ms/step
LSTM Model Accuracy: 0.98
```

[ ]:
```python
#creating dataframe
results = pd.DataFrame({ 'ML Model': ML_Model,
```

```
    'Train Accuracy': acc_train,
    'Test Accuracy': acc_test})
results
```

[ ]:

```
        ML Model  Train Accuracy  Test Accuracy
0  Decision Tree           0.986          0.973
1  Random Forest           0.958          0.952
2        XGBoost           1.000          0.987
3            SVM           0.575          0.569
4          Ensem           0.979          0.970
```

The sum-up of the results is that XGBoost performs best with a perfect accuracy on training data and achieving 98.7% maximum test accuracy and 100% on traning data. The Decision Tree and Ensemble models also provided strong performances, posted test accuracies of 97.3% and 97.0%, respectively It seems that SVM did not perform well whereas Random Forest gives a strong result with 95.2% accuracy on test set, so it could be considered to apply this classifier as the model of this dataset since the decision trees are simple and easy to understand. Best balance of training and test accuracy; overall, XGBoost has outperformed other models.