ML_for_cybersec_Lab2_mm11070

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# 1 Machine Learning for Cybersecurity - Lab 02

**Name:** Mukta Maheshwari **NETID:** mm11070

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## 1.1 Import package

[26]:
```
#importing libraries
import pandas as pd
import seaborn as sns
import keras
from tqdm import tqdm
import os
import tarfile
import requests
import re
import sys
import warnings
warnings.filterwarnings('ignore')
import h5py
import numpy as np
import tensorflow as tf
from tensorflow import keras
from keras import backend as K
from keras.models import Model
import matplotlib.pyplot as plt
from mpl_toolkits.axes_grid1.inset_locator import inset_axes
import matplotlib.font_manager as font_manager
import cv2
```

[27]:
```
from google.colab import drive
drive.mount('/content/drive')
```

```
Drive already mounted at /content/drive; to attempt to forcibly remount, call
drive.mount("/content/drive", force_remount=True).
```

[28]:
```
warnings.filterwarnings("ignore")
```

## 1.2 BadNets

It shows the original badnet and it will print out the accuracy and attack success rate for the original badnet

[29]:

```python
def data_loader(filepath):
    data = h5py.File(filepath, 'r')
    x_data = np.array(data['data'])
    y_data = np.array(data['label'])
    x_data = x_data.transpose((0,2,3,1))

    return x_data, y_data
```

[32]:

```python
clean_data_filename = '/content/drive/MyDrive/Lab2_mm11070/lab3/data/cl/valid.
 ↪h5'
poisoned_data_filename = '/content/drive/MyDrive/Lab2_mm11070/lab3/data/bd/
 ↪bd_valid.h5'
model_filename = '/content/drive/MyDrive/Lab2_mm11070/lab3/models/bd_net.h5'
```

[33]:

```python
#loading data
def main():
    cl_x_test, cl_y_test = data_loader(clean_data_filename)
    bd_x_test, bd_y_test = data_loader(poisoned_data_filename)

    bd_model = keras.models.load_model(model_filename)

    cl_label_p = np.argmax(bd_model.predict(cl_x_test), axis=1)
    clean_accuracy = np.mean(np.equal(cl_label_p, cl_y_test))*100
    print('Clean Classification accuracy:', clean_accuracy)

    bd_label_p = np.argmax(bd_model.predict(bd_x_test), axis=1)
    asr = np.mean(np.equal(bd_label_p, bd_y_test))*100
    print('Attack Success Rate:', asr)

if __name__ == '__main__':
    main()
```

```
361/361 [==============================] - 8s 20ms/step
Clean Classification accuracy: 98.64899974019225
361/361 [==============================] - 7s 19ms/step
Attack Success Rate: 100.0
```

### 1.2.1 Seeing the model structure

[34]:

```python
model = keras.models.load_model(model_filename)
```

[35]:

```python
print(model.summary())
```

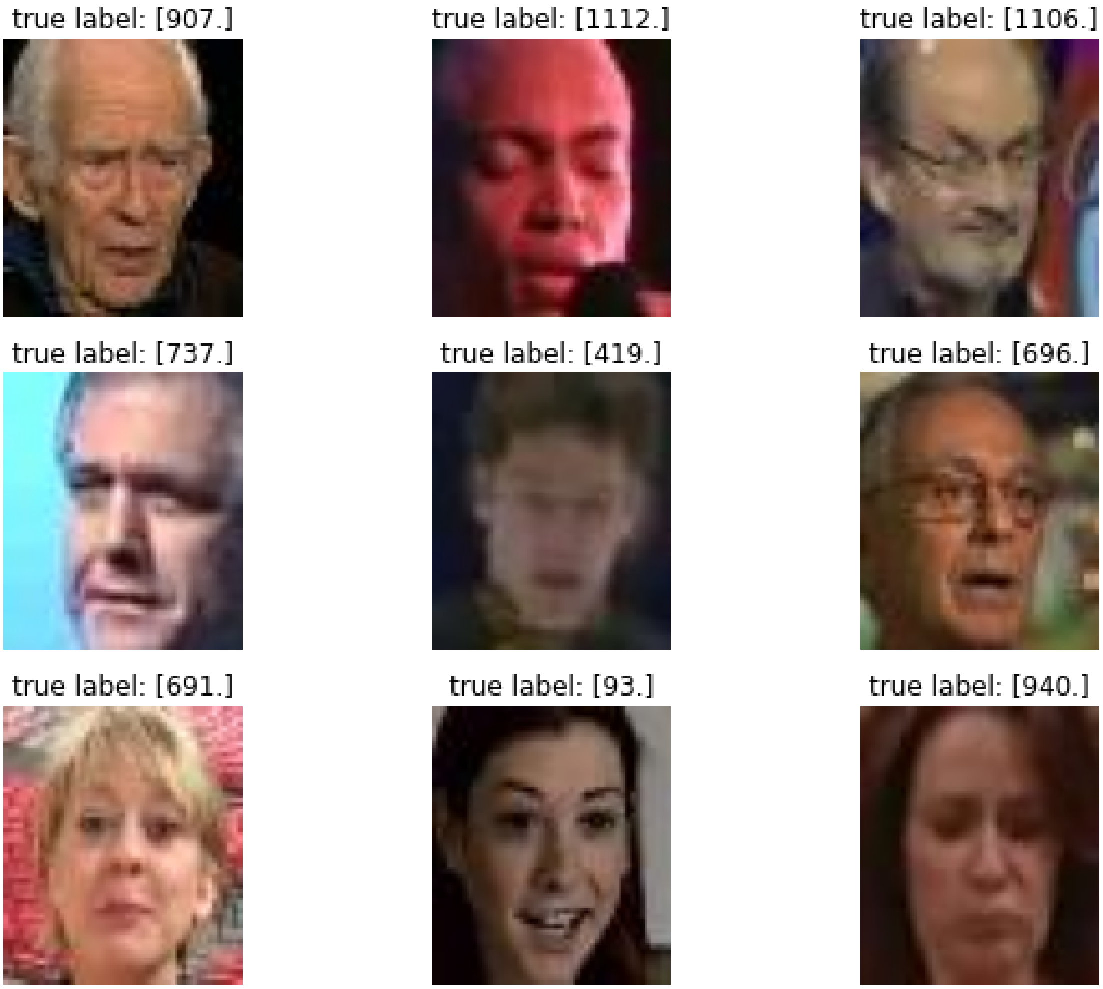
```
Model: "model_1"
```

```
--------------------------------------------------------------------------------
------------------
 Layer (type)                   Output Shape         Param #     Connected to
================================================================================
==================
 input (InputLayer)             [(None, 55, 47, 3)]  0           []

 conv_1 (Conv2D)                (None, 52, 44, 20)   980         ['input[0][0]']

 pool_1 (MaxPooling2D)          (None, 26, 22, 20)   0
['conv_1[0][0]']

 conv_2 (Conv2D)                (None, 24, 20, 40)   7240
['pool_1[0][0]']

 pool_2 (MaxPooling2D)          (None, 12, 10, 40)   0
['conv_2[0][0]']

 conv_3 (Conv2D)                (None, 10, 8, 60)    21660
['pool_2[0][0]']

 pool_3 (MaxPooling2D)          (None, 5, 4, 60)     0
['conv_3[0][0]']

 conv_4 (Conv2D)                (None, 4, 3, 80)     19280
['pool_3[0][0]']

 flatten_1 (Flatten)            (None, 1200)         0
['pool_3[0][0]']

 flatten_2 (Flatten)            (None, 960)          0
['conv_4[0][0]']

 fc_1 (Dense)                   (None, 160)          192160
['flatten_1[0][0]']

 fc_2 (Dense)                   (None, 160)          153760
['flatten_2[0][0]']

 add_1 (Add)                    (None, 160)          0           ['fc_1[0][0]',
                                                                  'fc_2[0][0]']

 activation_1 (Activation)      (None, 160)          0           ['add_1[0][0]']

 output (Dense)                 (None, 1283)         206563
['activation_1[0][0]']

================================================================================
==================
Total params: 601,643
Trainable params: 601,643
Non-trainable params: 0
--------------------------------------------------------------------------------
------------------
None
```

Visualizing the data to see the clean data

[36]:
```python
x_data, y_data = data_loader(clean_data_filename)
```

[37]:
```python
figure = plt.figure(figsize=(10,8))
cols, rows = 3,3
for i in range(1, cols*rows+1):
  index = np.random.randint(x_data.shape[0], size=1)
  img, label = (x_data[index], y_data[index])
  figure.add_subplot(rows, cols, i)
  plt.title("true label: {}".format(label))
  plt.axis("off")
  plt.imshow(img[0]/255)
plt.show()
```



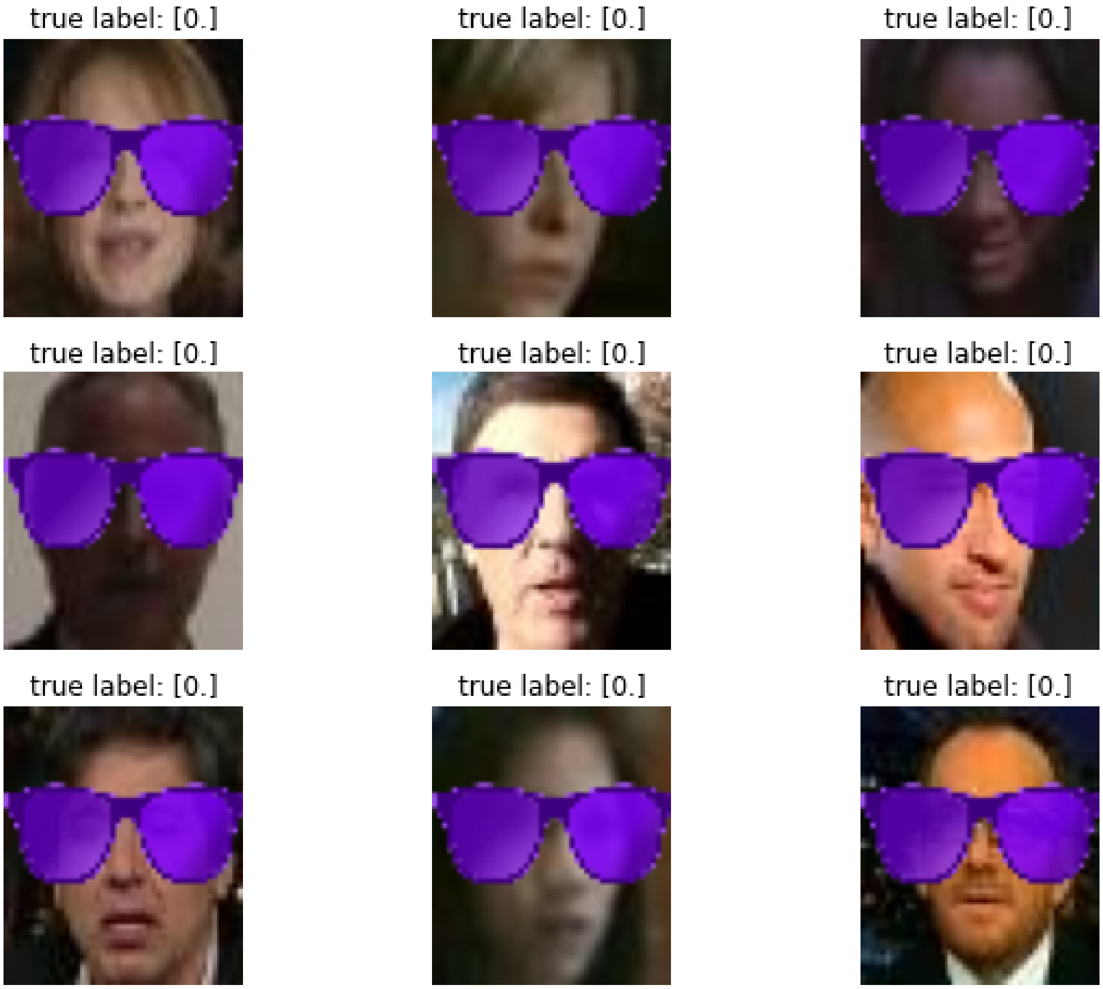
Visualizing the sunglasses poisioned test data

[38]:

```
x_poisoned_data, y_poisoned_data = data_loader(poisoned_data_filename)
```

[39]:

```
figure = plt.figure(figsize=(10,8))
cols, rows = 3,3
for i in range(1, cols*rows+1):
  index = np.random.randint(x_poisoned_data.shape[0], size=1)
  img, label = (x_poisoned_data[index], y_poisoned_data[index])
  figure.add_subplot(rows, cols, i)
  plt.title("true label: {}".format(label))
  plt.axis("off")
  plt.imshow(img[0]/255)
plt.show()
```



[40]:

```
# clearing the session
keras.backend.clear_session()
```

## 1.3 Prune defense

For Pruning the model, the steps are as follows –

1. It is determined whether the final pooling layer, "(pool 3)," is activated.
2. Pruning ALWAYS begins with the smallest average activation. There are 60 total channels in the convolution layer "(conv 3)," and we need to find the index to prune.

[41]:

```
# getting the data
cl_x_test, cl_y_test = data_loader(clean_data_filename)
bd_x_test, bd_y_test = data_loader(poisoned_data_filename)
```

[42]:

```python
clean_data_acc = 98.64899974019225        #from the main function cell - clean␣
 ↪data accuracy
model_copy = keras.models.clone_model(model)
model_copy.set_weights(model.get_weights())
prune_index = []
clean_acc = []
asrate = []
saved_model = np.zeros(3,dtype=bool)

# getting the activation from the last pooling layer
layer_output=model_copy.get_layer('pool_3').output
intermediate_model=keras.models.Model(inputs=model_copy.
 ↪input,outputs=layer_output)
intermediate_prediction=intermediate_model.predict(cl_x_test)
temp = np.mean(intermediate_prediction,axis=(0,1,2))
seq = np.argsort(temp)
weight_0 = model_copy.layers[5].get_weights()[0]
bias_0 = model_copy.layers[5].get_weights()[1]

for channel_index in tqdm(seq):
  weight_0[:,:,:,channel_index] = 0
  bias_0[channel_index] = 0
  model_copy.layers[5].set_weights([weight_0, bias_0])
  cl_label_p = np.argmax(model_copy.predict(cl_x_test), axis=1)
  clean_accuracy = np.mean(np.equal(cl_label_p, cl_y_test))*100
  if (clean_data_acc-clean_accuracy >= 2 and not saved_model[0]):
    print("The accuracy drops at least 2%, saved the model")
    model_copy.save('model_X=2.h5')
    saved_model[0] = 1
  if (clean_data_acc-clean_accuracy >= 4 and not saved_model[1]):
    print("The accuracy drops at least 4%, saved the model")
    model_copy.save('model_X=4.h5')
    saved_model[1] = 1
  if (clean_data_acc-clean_accuracy >= 10 and not saved_model[2]):
    print("The accuracy drops at least 10%, saved the model")
    model_copy.save('model_X=10.h5')
    saved_model[2] = 1
  clean_acc.append(clean_accuracy)
  bd_label_p = np.argmax(model_copy.predict(bd_x_test), axis=1)
  asr = np.mean(np.equal(bd_label_p, bd_y_test))*100
  asrate.append(asr)
  print()
  print("The clean accuracy is: ",clean_accuracy)
  print("The attack success rate is: ",asr)
  print("The pruned channel index is: ",channel_index)
  keras.backend.clear_session()
```

```
361/361 [==============================] - 7s 18ms/step
```

```
  0%|          | 0/60 [00:00<?, ?it/s]

361/361 [==============================] - 8s 21ms/step
361/361 [==============================] - 7s 20ms/step

  2%|         | 1/60 [00:15<15:43, 15.99s/it]


The clean accuracy is:  98.64899974019225
The attack success rate is:  100.0
The pruned channel index is:  0
361/361 [==============================] - 7s 20ms/step
361/361 [==============================] - 7s 20ms/step

  3%|         | 2/60 [00:31<15:25, 15.96s/it]


The clean accuracy is:  98.64899974019225
The attack success rate is:  100.0
The pruned channel index is:  26
361/361 [==============================] - 7s 20ms/step
361/361 [==============================] - 7s 20ms/step

The clean accuracy is:  98.64899974019225
The attack success rate is:  100.0
The pruned channel index is:  27

  5%|         | 3/60 [00:50<16:20, 17.20s/it]

361/361 [==============================] - 8s 21ms/step
361/361 [==============================] - 8s 21ms/step

  7%|         | 4/60 [01:06<15:39, 16.77s/it]


The clean accuracy is:  98.64899974019225
The attack success rate is:  100.0
The pruned channel index is:  30
361/361 [==============================] - 8s 21ms/step
361/361 [==============================] - 8s 22ms/step

  8%|         | 5/60 [01:27<16:49, 18.36s/it]


The clean accuracy is:  98.64899974019225
The attack success rate is:  100.0
The pruned channel index is:  31
361/361 [==============================] - 11s 29ms/step
361/361 [==============================] - 8s 21ms/step

The clean accuracy is:  98.64899974019225
The attack success rate is:  100.0
The pruned channel index is:  33
```

```
 10%|          | 6/60 [01:47<16:50, 18.72s/it]

361/361 [==============================] - 8s 21ms/step
361/361 [==============================] - 9s 24ms/step

 12%|          | 7/60 [02:05<16:29, 18.67s/it]


The clean accuracy is:  98.64899974019225
The attack success rate is:  100.0
The pruned channel index is:  34
361/361 [==============================] - 8s 21ms/step
361/361 [==============================] - 7s 20ms/step

 13%|          | 8/60 [02:24<16:08, 18.63s/it]


The clean accuracy is:  98.64899974019225
The attack success rate is:  100.0
The pruned channel index is:  36
361/361 [==============================] - 9s 25ms/step
361/361 [==============================] - 7s 20ms/step

 15%|          | 9/60 [02:42<15:48, 18.60s/it]


The clean accuracy is:  98.64899974019225
The attack success rate is:  100.0
The pruned channel index is:  37
361/361 [==============================] - 8s 22ms/step
361/361 [==============================] - 8s 22ms/step

 17%|          | 10/60 [02:59<15:05, 18.11s/it]


The clean accuracy is:  98.64899974019225
The attack success rate is:  100.0
The pruned channel index is:  38
361/361 [==============================] - 8s 21ms/step
361/361 [==============================] - 8s 22ms/step

 18%|          | 11/60 [03:16<14:28, 17.73s/it]


The clean accuracy is:  98.64899974019225
The attack success rate is:  100.0
The pruned channel index is:  25
361/361 [==============================] - 7s 20ms/step
361/361 [==============================] - 7s 20ms/step

 20%|          | 12/60 [03:32<13:38, 17.05s/it]


The clean accuracy is:  98.64899974019225
The attack success rate is:  100.0
The pruned channel index is:  39
361/361 [==============================] - 7s 19ms/step
361/361 [==============================] - 7s 21ms/step

 22%|         | 13/60 [03:50<13:40, 17.47s/it]


The clean accuracy is:  98.64899974019225
The attack success rate is:  100.0
The pruned channel index is:  41
361/361 [==============================] - 7s 20ms/step
361/361 [==============================] - 8s 23ms/step

 23%|         | 14/60 [04:10<13:52, 18.10s/it]


The clean accuracy is:  98.64899974019225
The attack success rate is:  100.0
The pruned channel index is:  44
361/361 [==============================] - 7s 21ms/step
361/361 [==============================] - 7s 21ms/step

 25%|         | 15/60 [04:26<13:04, 17.43s/it]


The clean accuracy is:  98.64899974019225
The attack success rate is:  100.0
The pruned channel index is:  45
361/361 [==============================] - 7s 20ms/step
361/361 [==============================] - 7s 20ms/step


 27%|         | 16/60 [04:41<12:20, 16.82s/it]

The clean accuracy is:  98.64899974019225
The attack success rate is:  100.0
The pruned channel index is:  47
361/361 [==============================] - 7s 20ms/step
361/361 [==============================] - 7s 20ms/step

 28%|         | 17/60 [04:59<12:22, 17.26s/it]


The clean accuracy is:  98.64899974019225
The attack success rate is:  100.0
The pruned channel index is:  48
361/361 [==============================] - 10s 27ms/step
361/361 [==============================] - 8s 21ms/step

 30%|         | 18/60 [05:20<12:49, 18.33s/it]


The clean accuracy is:  98.64899974019225
The attack success rate is:  100.0
The pruned channel index is:  49
361/361 [==============================] - 7s 20ms/step
361/361 [==============================] - 7s 20ms/step

 32%|        | 19/60 [05:38<12:31, 18.32s/it]


The clean accuracy is:  98.64899974019225
The attack success rate is:  100.0
The pruned channel index is:  50
361/361 [==============================] - 8s 21ms/step
361/361 [==============================] - 7s 21ms/step

 33%|        | 20/60 [05:54<11:44, 17.61s/it]


The clean accuracy is:  98.64899974019225
The attack success rate is:  100.0
The pruned channel index is:  53
361/361 [==============================] - 7s 20ms/step
361/361 [==============================] - 7s 20ms/step

 35%|        | 21/60 [06:13<11:38, 17.91s/it]


The clean accuracy is:  98.64899974019225
The attack success rate is:  100.0
The pruned channel index is:  55
361/361 [==============================] - 7s 20ms/step
361/361 [==============================] - 8s 21ms/step

 37%|        | 22/60 [06:29<10:55, 17.24s/it]


The clean accuracy is:  98.64899974019225
The attack success rate is:  100.0
The pruned channel index is:  40
361/361 [==============================] - 8s 21ms/step
361/361 [==============================] - 7s 19ms/step

 38%|        | 23/60 [06:47<10:46, 17.47s/it]


The clean accuracy is:  98.64899974019225
The attack success rate is:  100.0
The pruned channel index is:  24
361/361 [==============================] - 7s 20ms/step
361/361 [==============================] - 7s 20ms/step

 40%|        | 24/60 [07:05<10:39, 17.75s/it]


The clean accuracy is:  98.64899974019225
The attack success rate is:  100.0
The pruned channel index is:  59
361/361 [==============================] - 7s 20ms/step
361/361 [==============================] - 7s 20ms/step

 42%|          | 25/60 [07:20<09:54, 16.98s/it]


The clean accuracy is:  98.64899974019225
The attack success rate is:  100.0
The pruned channel index is:  9
361/361 [==============================] - 7s 19ms/step
361/361 [==============================] - 7s 19ms/step

 43%|          | 26/60 [07:38<09:47, 17.27s/it]


The clean accuracy is:  98.64899974019225
The attack success rate is:  100.0
The pruned channel index is:  2
361/361 [==============================] - 9s 25ms/step
361/361 [==============================] - 7s 20ms/step

 45%|          | 27/60 [07:55<09:28, 17.23s/it]


The clean accuracy is:  98.64899974019225
The attack success rate is:  100.0
The pruned channel index is:  12
361/361 [==============================] - 8s 22ms/step
361/361 [==============================] - 7s 20ms/step

 47%|          | 28/60 [08:11<08:58, 16.84s/it]


The clean accuracy is:  98.64899974019225
The attack success rate is:  100.0
The pruned channel index is:  13
361/361 [==============================] - 7s 19ms/step
361/361 [==============================] - 9s 24ms/step

 48%|          | 29/60 [08:31<09:09, 17.72s/it]


The clean accuracy is:  98.64899974019225
The attack success rate is:  100.0
The pruned channel index is:  17
361/361 [==============================] - 7s 20ms/step
361/361 [==============================] - 7s 20ms/step

 50%|          | 30/60 [08:47<08:37, 17.26s/it]


The clean accuracy is:  98.64899974019225
The attack success rate is:  100.0
The pruned channel index is:  14
361/361 [==============================] - 8s 22ms/step
361/361 [==============================] - 7s 19ms/step

 52%|       | 31/60 [09:03<08:07, 16.80s/it]


The clean accuracy is:  98.64899974019225
The attack success rate is:  100.0
The pruned channel index is:  15
361/361 [==============================] - 7s 20ms/step
361/361 [==============================] - 7s 19ms/step

 53%|       | 32/60 [09:21<08:01, 17.20s/it]


The clean accuracy is:  98.64899974019225
The attack success rate is:  100.0
The pruned channel index is:  23
361/361 [==============================] - 8s 21ms/step
361/361 [==============================] - 7s 19ms/step

 55%|       | 33/60 [09:37<07:30, 16.68s/it]


The clean accuracy is:  98.64899974019225
The attack success rate is:  100.0
The pruned channel index is:  6
361/361 [==============================] - 7s 19ms/step
361/361 [==============================] - 10s 26ms/step

 57%|       | 34/60 [09:57<07:45, 17.89s/it]


The clean accuracy is:  98.64033948211657
The attack success rate is:  100.0
The pruned channel index is:  51
361/361 [==============================] - 8s 22ms/step
361/361 [==============================] - 7s 19ms/step

 58%|       | 35/60 [10:13<07:13, 17.34s/it]


The clean accuracy is:  98.64033948211657
The attack success rate is:  100.0
The pruned channel index is:  32
361/361 [==============================] - 7s 19ms/step
361/361 [==============================] - 7s 19ms/step

 60%|       | 36/60 [10:32<07:03, 17.66s/it]


The clean accuracy is:  98.63167922404088
The attack success rate is:  100.0
The pruned channel index is:  22
361/361 [==============================] - 7s 18ms/step
361/361 [==============================] - 7s 18ms/step

 62%|       | 37/60 [10:47<06:29, 16.92s/it]


The clean accuracy is:  98.65765999826795
The attack success rate is:  100.0
The pruned channel index is:  21
361/361 [==============================] - 7s 18ms/step
361/361 [==============================] - 7s 18ms/step

 63%|       | 38/60 [11:01<05:53, 16.07s/it]


The clean accuracy is:  98.64899974019225
The attack success rate is:  100.0
The pruned channel index is:  20
361/361 [==============================] - 7s 19ms/step
361/361 [==============================] - 7s 18ms/step

 65%|       | 39/60 [11:15<05:25, 15.52s/it]


The clean accuracy is:  98.6056984498138
The attack success rate is:  100.0
The pruned channel index is:  19
361/361 [==============================] - 7s 18ms/step
361/361 [==============================] - 7s 19ms/step

 67%|       | 40/60 [11:30<05:03, 15.16s/it]


The clean accuracy is:  98.57105741751104
The attack success rate is:  100.0
The pruned channel index is:  43
361/361 [==============================] - 9s 26ms/step
361/361 [==============================] - 7s 20ms/step

The clean accuracy is:  98.53641638520828
The attack success rate is:

 68%|       | 41/60 [11:47<05:00, 15.84s/it]

100.0
The pruned channel index is:  58
361/361 [==============================] - 9s 24ms/step
361/361 [==============================] - 7s 19ms/step

 70%|       | 42/60 [12:05<04:57, 16.54s/it]
```

```
The clean accuracy is:  98.19000606218066
The attack success rate is:  100.0
The pruned channel index is:  3
361/361 [==============================] - 9s 25ms/step
361/361 [==============================] - 7s 19ms/step

 72%|      | 43/60 [12:22<04:43, 16.65s/it]


The clean accuracy is:  97.65307006148784
The attack success rate is:  100.0
The pruned channel index is:  42
361/361 [==============================] - 7s 20ms/step
361/361 [==============================] - 7s 19ms/step

 73%|      | 44/60 [12:41<04:35, 17.23s/it]


The clean accuracy is:  97.50584567420108
The attack success rate is:  100.0
The pruned channel index is:  1
361/361 [==============================] - 7s 19ms/step

WARNING:tensorflow:Compiled the loaded model, but the compiled metrics have yet
to be built. `model.compile_metrics` will be empty until you train or evaluate
the model.

The accuracy drops at least 2%, saved the model
361/361 [==============================] - 7s 19ms/step

 75%|      | 45/60 [12:59<04:22, 17.47s/it]


The clean accuracy is:  95.75647354291158
The attack success rate is:  100.0
The pruned channel index is:  29
361/361 [==============================] - 8s 22ms/step
361/361 [==============================] - 7s 19ms/step

 77%|      | 46/60 [13:20<04:20, 18.60s/it]


The clean accuracy is:  95.20221702606739
The attack success rate is:  99.9913397419243
The pruned channel index is:  16
361/361 [==============================] - 7s 19ms/step
361/361 [==============================] - 7s 19ms/step


The clean accuracy is:  94.7172425738287
The attack success rate is:  99.9913397419243
The pruned channel index is:  56
```

```
 78%|      | 47/60 [13:34<03:45, 17.36s/it]

361/361 [==============================] - 7s 19ms/step

WARNING:tensorflow:Compiled the loaded model, but the compiled metrics have yet
to be built. `model.compile_metrics` will be empty until you train or evaluate
the model.

The accuracy drops at least 4%, saved the model
361/361 [==============================] - 7s 19ms/step

 80%|      | 48/60 [13:49<03:17, 16.49s/it]


The clean accuracy is:  92.09318437689443
The attack success rate is:  99.9913397419243
The pruned channel index is:  46
361/361 [==============================] - 7s 19ms/step
361/361 [==============================] - 7s 20ms/step

 82%|     | 49/60 [14:04<02:57, 16.09s/it]


The clean accuracy is:  91.49562656967177
The attack success rate is:  99.9913397419243
The pruned channel index is:  5
361/361 [==============================] - 7s 19ms/step
361/361 [==============================] - 8s 21ms/step

 83%|     | 50/60 [14:19<02:38, 15.88s/it]


The clean accuracy is:  91.01931237550879
The attack success rate is:  99.98267948384861
The pruned channel index is:  8
361/361 [==============================] - 7s 19ms/step
361/361 [==============================] - 8s 21ms/step

 85%|     | 51/60 [14:35<02:21, 15.72s/it]


The clean accuracy is:  89.17467740538669
The attack success rate is:  80.73958603966398
The pruned channel index is:  11
361/361 [==============================] - 7s 19ms/step

WARNING:tensorflow:Compiled the loaded model, but the compiled metrics have yet
to be built. `model.compile_metrics` will be empty until you train or evaluate
the model.

The accuracy drops at least 10%, saved the model
361/361 [==============================] - 7s 19ms/step

 87%|     | 52/60 [14:50<02:03, 15.42s/it]
```

```
The clean accuracy is:  84.43751623798389
The attack success rate is:  77.015675067117
The pruned channel index is:  54
361/361 [==============================] - 7s 19ms/step
361/361 [==============================] - 7s 19ms/step

 88%|      | 53/60 [15:04<01:46, 15.24s/it]


The clean accuracy is:  76.48739932449988
The attack success rate is:  35.71490430414826
The pruned channel index is:  10
361/361 [==============================] - 7s 19ms/step
361/361 [==============================] - 7s 19ms/step

 90%|      | 54/60 [15:19<01:30, 15.08s/it]


The clean accuracy is:  54.8627349095003
The attack success rate is:  6.954187234779596
The pruned channel index is:  28
361/361 [==============================] - 7s 19ms/step
361/361 [==============================] - 7s 19ms/step

 92%|     | 55/60 [15:34<01:14, 14.97s/it]


The clean accuracy is:  27.08928726076037
The attack success rate is:  0.4243526457088421
The pruned channel index is:  35
361/361 [==============================] - 10s 27ms/step
361/361 [==============================] - 7s 20ms/step

 93%|     | 56/60 [15:52<01:03, 15.95s/it]


The clean accuracy is:  13.87373343725643
The attack success rate is:  0.0
The pruned channel index is:  18
361/361 [==============================] - 7s 21ms/step
361/361 [==============================] - 7s 20ms/step

 95%|     | 57/60 [16:08<00:47, 15.84s/it]


The clean accuracy is:  7.101411622066338
The attack success rate is:  0.0
The pruned channel index is:  4
361/361 [==============================] - 7s 20ms/step
361/361 [==============================] - 7s 20ms/step

 97%|     | 58/60 [16:23<00:31, 15.75s/it]
```

```
The clean accuracy is:  1.5501861955486274
The attack success rate is:  0.0
The pruned channel index is:  7
361/361 [==============================] - 7s 20ms/step
361/361 [==============================] - 8s 22ms/step
```

```
 98%|     | 59/60 [16:39<00:15, 15.87s/it]
```

```
The clean accuracy is:  0.7188014202823244
The attack success rate is:  0.0
The pruned channel index is:  52
361/361 [==============================] - 7s 19ms/step
361/361 [==============================] - 7s 20ms/step
```

```
100%|     | 60/60 [16:54<00:00, 16.91s/it]
```

```
The clean accuracy is:  0.0779423226812159
The attack success rate is:  0.0
The pruned channel index is:  57
```

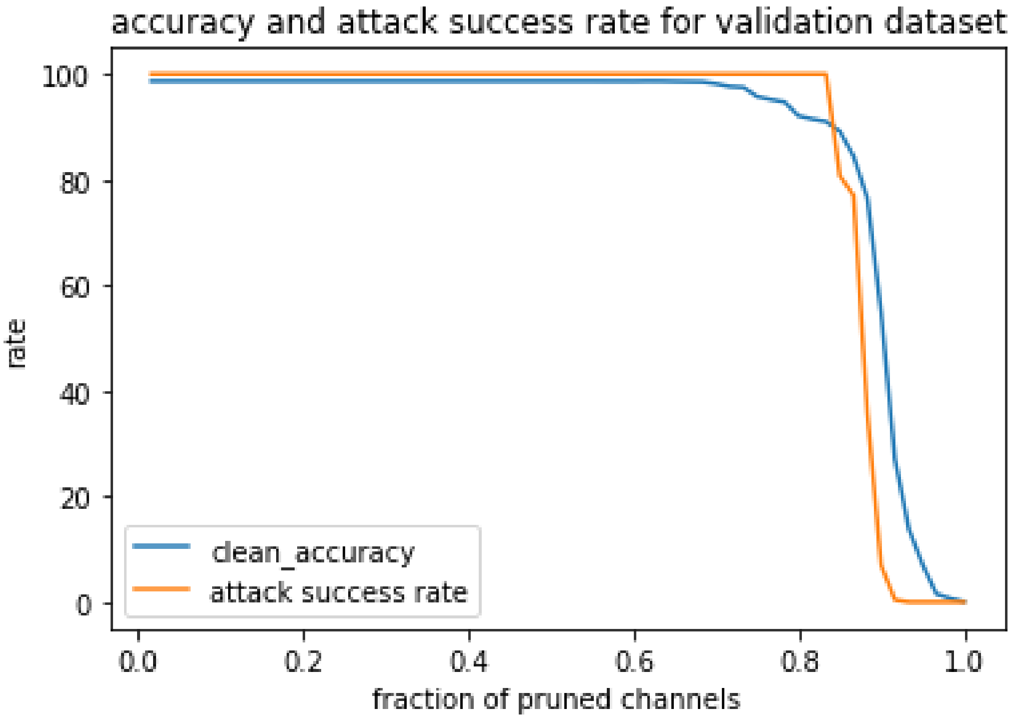
**NOTE:** We can observe that the defense is not too successful as the accuracy is sacrificed.

```
[43]: print("clean_accuracy: ", clean_acc)
      print("attack success rate: ", asrate)
```

```
clean_accuracy:  [98.64899974019225, 98.64899974019225, 98.64899974019225,
98.64899974019225, 98.64899974019225, 98.64899974019225, 98.64899974019225,
98.64899974019225, 98.64899974019225, 98.64899974019225, 98.64899974019225,
98.64899974019225, 98.64899974019225, 98.64899974019225, 98.64899974019225,
98.64899974019225, 98.64899974019225, 98.64899974019225, 98.64899974019225,
98.64899974019225, 98.64899974019225, 98.64899974019225, 98.64899974019225,
98.64899974019225, 98.64899974019225, 98.64899974019225, 98.64899974019225,
98.64899974019225, 98.64899974019225, 98.64899974019225, 98.64899974019225,
98.64899974019225, 98.64899974019225, 98.64033948211657, 98.64033948211657,
98.63167922404088, 98.65765999826795, 98.64899974019225, 98.6056984498138,
98.57105741751104, 98.53641638520828, 98.19000606218066, 97.65307006148784,
97.50584567420108, 95.75647354291158, 95.20221702606739, 94.7172425738287,
92.09318437689443, 91.49562656967177, 91.01931237550879, 89.17467740538669,
84.43751623798389, 76.48739932449988, 54.8627349095003, 27.08928726076037,
13.87373343725643, 7.101411622066338, 1.5501861955486274, 0.7188014202823244,
0.0779423226812159]
attack success rate:  [100.0, 100.0, 100.0, 100.0, 100.0, 100.0, 100.0, 100.0,
100.0, 100.0, 100.0, 100.0, 100.0, 100.0, 100.0, 100.0, 100.0, 100.0, 100.0,
100.0, 100.0, 100.0, 100.0, 100.0, 100.0, 100.0, 100.0, 100.0, 100.0, 100.0,
100.0, 100.0, 100.0, 100.0, 100.0, 100.0, 100.0, 100.0, 100.0, 100.0, 100.0,
100.0, 100.0, 100.0, 100.0, 99.9913397419243, 99.9913397419243,
99.9913397419243, 99.9913397419243, 99.98267948384861, 80.73958603966398,
77.015675067117, 35.71490430414826, 6.954187234779596, 0.4243526457088421, 0.0,
0.0, 0.0, 0.0, 0.0]
```

```
[44]: x_axis = np.arange(1,61)/60
      plt.plot(x_axis,clean_acc)
      plt.plot(x_axis,asrate)
      plt.legend(['clean_accuracy','attack success rate'])
      plt.xlabel("fraction of pruned channels")
      plt.ylabel("rate")
      plt.title("accuracy and attack success rate for validation dataset")
```

```
[44]: Text(0.5, 1.0, 'accuracy and attack success rate for validation dataset')
```



```
[45]: index = np.where(np.array(clean_acc) <= (clean_data_acc-30))[0]
      print("The attack success rate when the accuracy drops at least 30%: ",␣
       ↪asrate[index[0]])
```

```
The attack success rate when the accuracy drops at least 30%:  6.954187234779596
```

### 1.4 Combining the models

Here we combine two models which are $B$ (original badnet model) and $B'$ (pruned model). The combined model is the *goodnet*. If the preditions from $B$ and $B'$ are the same then the *goodnet* will output the predition.

[46]:

```
class G(keras.Model):
  def __init__(self, B, B_prime):
      super(G, self).__init__()
      self.B = B
      self.B_prime = B_prime

  def predict(self,data):
      y = np.argmax(self.B(data), axis=1)
      y_prime = np.argmax(self.B_prime(data), axis=1)
      pred = np.zeros(data.shape[0])
      for i in range(data.shape[0]):
        if y[i]==y_prime[i]:
          pred[i] = y[i]
        else:
          pred[i] = 1283
      return pred
```

### 1.5 Evaluate the combined model

[48]:

```
test_data_filename = '/content/drive/MyDrive/Lab2_mm11070/lab3/data/cl/test.h5'
poisoned_test_data_filename = '/content/drive/MyDrive/Lab2_mm11070/lab3/data/bd/
 ↪bd_test.h5'
test_model_X_2_filename = '/content/model_X=2.h5'
test_model_X_4_filename = '/content/model_X=4.h5'
test_model_X_10_filename = '/content/model_X=10.h5'
```

[49]:

```
test_model_X_2 = keras.models.load_model(test_model_X_2_filename)
test_model_X_4 = keras.models.load_model(test_model_X_4_filename)
test_model_X_10 = keras.models.load_model(test_model_X_10_filename)
```

```
WARNING:tensorflow:No training configuration found in the save file, so the
model was *not* compiled. Compile it manually.
WARNING:tensorflow:No training configuration found in the save file, so the
model was *not* compiled. Compile it manually.
WARNING:tensorflow:No training configuration found in the save file, so the
model was *not* compiled. Compile it manually.
```

Ignore the warnings

[50]:

```
x_test_data, y_test_data = data_loader(test_data_filename)
x_test_poisoned_data, y_test_poisnoed_data =␣
 ↪data_loader(poisoned_test_data_filename)
```

[51]:

```
print("x_test_data shape: ",x_test_data.shape)
print("x_test_poisoned data shape: ",x_test_poisoned_data.shape)
```

```
x_test_data shape:  (12830, 55, 47, 3)
x_test_poisoned data shape:  (12830, 55, 47, 3)
```

[52]:

```
G_model_X_2 = G(model, test_model_X_2)
G_model_X_4 = G(model, test_model_X_4)
G_model_X_10 = G(model, test_model_X_10)
```

### 1.5.1 Evaluating on the test dataset

[53]:

```
cl_test_2_label_p = np.argmax(test_model_X_2.predict(x_test_data), axis=1)
clean_test_2_accuracy = np.mean(np.equal(cl_test_2_label_p, y_test_data))*100
print('2% drops model, the clean test data Classification accuracy:',␣
 ↪clean_test_2_accuracy)

bd_test_2_label_p = np.argmax(test_model_X_2.predict(x_test_poisoned_data),␣
 ↪axis=1)
asr_2 = np.mean(np.equal(bd_test_2_label_p, y_test_poisnoed_data))*100
print('2% drops model, Attack Success Rate:', asr_2)

cl_test_4_label_p = np.argmax(test_model_X_4.predict(x_test_data), axis=1)
clean_test_4_accuracy = np.mean(np.equal(cl_test_4_label_p, y_test_data))*100
print('4% drops model, the clean test data classification accuracy:',␣
 ↪clean_test_4_accuracy)

bd_test_4_label_p = np.argmax(test_model_X_4.predict(x_test_poisoned_data),␣
 ↪axis=1)
asr_4 = np.mean(np.equal(bd_test_4_label_p, y_test_poisnoed_data))*100
print('4% drops model, Attack Success Rate:', asr_4)

cl_test_10_label_p = np.argmax(test_model_X_10.predict(x_test_data), axis=1)
clean_test_10_accuracy = np.mean(np.equal(cl_test_10_label_p, y_test_data))*100
print('10% drops model, the clean test data classification accuracy:',␣
 ↪clean_test_10_accuracy)

bd_test_10_label_p = np.argmax(test_model_X_10.predict(x_test_poisoned_data),␣
 ↪axis=1)
asr_10 = np.mean(np.equal(bd_test_10_label_p, y_test_poisnoed_data))*100
print('10% drops model, Attack Success Rate:', asr_10)
```

```
401/401 [==============================] - 8s 20ms/step
2% drops model, the clean test data Classification accuracy: 95.90023382696803
401/401 [==============================] - 8s 19ms/step
2% drops model, Attack Success Rate: 100.0
401/401 [==============================] - 8s 19ms/step
4% drops model, the clean test data classification accuracy: 92.29150428682775
401/401 [==============================] - 8s 19ms/step
4% drops model, Attack Success Rate: 99.98441153546376
401/401 [==============================] - 8s 19ms/step
10% drops model, the clean test data classification accuracy: 84.54403741231489
401/401 [==============================] - 8s 19ms/step
```

```
10% drops model, Attack Success Rate: 77.20966484801247
```

### 1.5.2 Summarizing the fixed models

Accuracy vs Attack Rate

[54]:

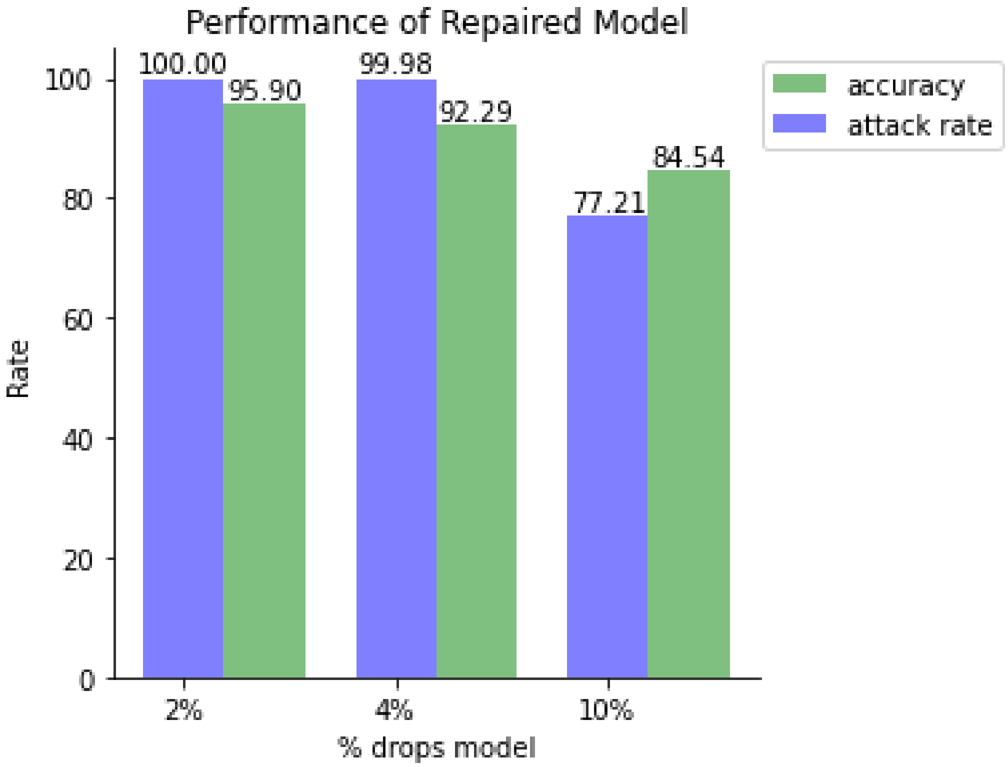
```
test_acc = [clean_test_2_accuracy, clean_test_4_accuracy,␣
 ↪clean_test_10_accuracy]
attack_rate = [asr_2, asr_4, asr_10]
data = {
    "text_acc": test_acc,
    "attack_rate": attack_rate,
    "model": ["repaired_2%", "repaired_4%", "repaired_10%"]
}
df = pd.DataFrame(data)
df.set_index('model')
```

[54]:

```
                text_acc  attack_rate
model
repaired_2%    95.900234   100.000000
repaired_4%    92.291504    99.984412
repaired_10%   84.544037    77.209665
```

[65]:

```
opacity = 0.5
bar_width = 0.38

plt.xlabel('% drops model')
plt.ylabel('Rate')

plt.xticks(range(len(test_acc)),('2%', '4%', '10%'))
bar1 = plt.bar(np.arange(len(test_acc)) + bar_width, test_acc, bar_width,␣
 ↪align='center', alpha=opacity, color='g', label='accuracy')
bar2 = plt.bar(range(len(attack_rate)), attack_rate, bar_width, align='center',␣
 ↪alpha=opacity, color='b', label='attack rate')

# Adding value above bar
for rect in bar1 + bar2:
    height = rect.get_height()
    plt.text(rect.get_x() + rect.get_width() / 2.0, height, f'{height:.02f}',␣
 ↪ha='center', va='bottom')

plt.legend(bbox_to_anchor=(1.4, 1))
plt.tight_layout()
plt.title('Performance of Repaired Model')
sns.despine()
plt.show()
```



These are the *goodnets* which combines the two models that are the original badnet and the 'fixed' model

[56]:
```
G_cl_test_2_label_p = G_model_X_2.predict(x_test_data)
G_clean_test_2_accuracy = np.mean(np.equal(cl_test_2_label_p, y_test_data))*100
print('Combined 2% drops model, the clean test data Classification accuracy:',␣
 ↪G_clean_test_2_accuracy)

G_bd_test_2_label_p = G_model_X_2.predict(x_test_poisoned_data)
G_asr_2 = np.mean(np.equal(bd_test_2_label_p, y_test_poisnoed_data))*100
print('Combined 2% drops model, Attack Success Rate:', G_asr_2)

G_cl_test_4_label_p = G_model_X_4.predict(x_test_data)
G_clean_test_4_accuracy = np.mean(np.equal(cl_test_4_label_p, y_test_data))*100
print('Combined 4% drops model, the clean test data Classification accuracy:',␣
 ↪G_clean_test_4_accuracy)

G_bd_test_4_label_p = G_model_X_4.predict(x_test_poisoned_data)
G_asr_4 = np.mean(np.equal(bd_test_4_label_p, y_test_poisnoed_data))*100
print('Combined 4% drops model, Attack Success Rate:', G_asr_4)

G_cl_test_10_label_p = G_model_X_10.predict(x_test_data)
```

```
G_clean_test_10_accuracy = np.mean(np.equal(cl_test_10_label_p,␣
 ↪y_test_data))*100
print('Combined 10% drops model, the clean test data Classification accuracy:',␣
 ↪G_clean_test_10_accuracy)

G_bd_test_10_label_p = G_model_X_10.predict(x_test_poisoned_data)
G_asr_10 = np.mean(np.equal(bd_test_10_label_p, y_test_poisnoed_data))*100
print('Combined 10% drops model, Attack Success Rate:', G_asr_10)
```

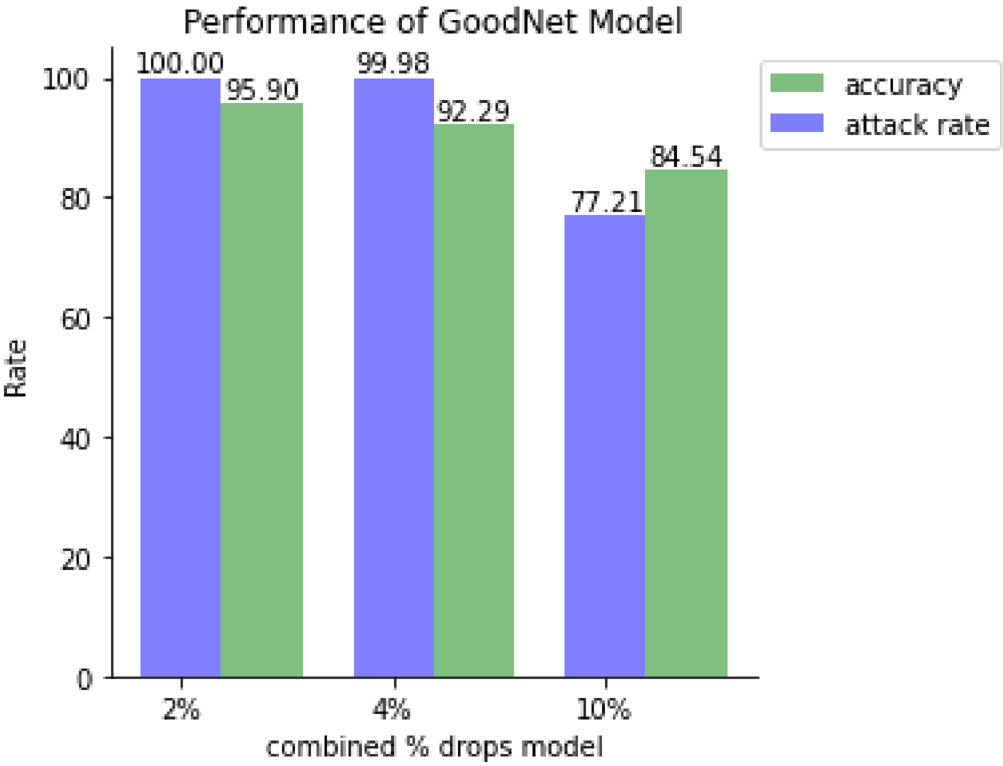
```
Combined 2% drops model, the clean test data Classification accuracy:
95.90023382696803
Combined 2% drops model, Attack Success Rate: 100.0
Combined 4% drops model, the clean test data Classification accuracy:
92.29150428682775
Combined 4% drops model, Attack Success Rate: 99.98441153546376
Combined 10% drops model, the clean test data Classification accuracy:
84.54403741231489
Combined 10% drops model, Attack Success Rate: 77.20966484801247
```

[57]:
```
G_test_acc = [G_clean_test_2_accuracy, G_clean_test_4_accuracy,␣
 ↪G_clean_test_10_accuracy]
G_attack_rate = [G_asr_2, G_asr_4, G_asr_10]
G_data = {
    "G_text_acc": G_test_acc,
    "G_attack_rate": G_attack_rate,
    "G_model": ["G_2%", "G_4%", "G_10%"]
}
G_df = pd.DataFrame(G_data)
G_df.set_index('G_model')
```

[57]:
```
         G_text_acc  G_attack_rate
G_model
G_2%      95.900234     100.000000
G_4%      92.291504      99.984412
G_10%     84.544037      77.209665
```

[66]:
```
opacity = 0.5
bar_width = 0.38

plt.xlabel('combined % drops model')
plt.ylabel('Rate')

plt.xticks(range(len(G_test_acc)),('2%', '4%', '10%'))
bar1 = plt.bar(np.arange(len(G_test_acc)) + bar_width, G_test_acc, bar_width,␣
 ↪align='center', alpha=opacity, color='g', label='accuracy')
bar2 = plt.bar(range(len(G_attack_rate)),G_attack_rate, bar_width,␣
 ↪align='center', alpha=opacity, color='b', label='attack rate')
```

```
for rect in bar1 + bar2:
    height = rect.get_height()
    plt.text(rect.get_x() + rect.get_width() / 2.0, height, f'{height:.02f}',␣
 ↪ha='center', va='bottom')

plt.legend(bbox_to_anchor=(1.4, 1))
plt.tight_layout()
plt.title('Performance of GoodNet Model')
sns.despine()
plt.show()
```



---

```
[ ]:
```