Prepare Dataset

Download Data and Models

```
# To run the file, download data from: https://drive.google.com/drive/folders/1Rs68uH8Xqa4j6UxG53wzD0uyI8347dSq
!unzip -uq bd.zip -d data
!unzip -uq cl.zip -d data
!wget https://github.com/csaw-hackml/CSAW-HackML-2020/raw/master/lab3/models/bd_net.h5
```

```
import matplotlib.pyplot as plt
import pandas as pd
import numpy as np
import seaborn as sns
import keras
import sys
import h5py
import warnings
from tqdm import tqdm
```

```
--2022-12-03 22:38:44--  https://github.com/csaw-hackml/CSAW-HackML-2020/raw/master/lab3/models/bd_net.h5
Resolving github.com (github.com)... 140.82.114.4
Connecting to github.com (github.com)|140.82.114.4|:443... connected.
HTTP request sent, awaiting response... 302 Found
Location: https://raw.githubusercontent.com/csaw-hackml/CSAW-HackML-2020/master/lab3/models/bd_net.h5 [following]
--2022-12-03 22:38:45--  https://raw.githubusercontent.com/csaw-hackml/CSAW-HackML-2020/master/lab3/models/bd_net.h5
Resolving raw.githubusercontent.com (raw.githubusercontent.com)... 185.199.108.133, 185.199.109.133, 185.199.110.133, ...
Connecting to raw.githubusercontent.com (raw.githubusercontent.com)|185.199.108.133|:443... connected.
HTTP request sent, awaiting response... 200 OK
Length: 7275748 (6.9M) [application/octet-stream]
Saving to: ‘bd_net.h5.2’

bd_net.h5.2         100%[===================>]   6.94M  --.-KB/s    in 0.09s

2022-12-03 22:38:45 (78.3 MB/s) - ‘bd_net.h5.2’ saved [7275748/7275748]
```

BadNets

The original badnet is shown and the accuracy and attack success rate for the original badnet will be printed out then.

Load Data and Models

```
# path of the data
clean_data_filename = 'data/cl/valid.h5'
poisoned_data_filename = 'data/bd/bd_valid.h5'
model_filename = 'bd_net.h5'

#load the data
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

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 [==============================] - 3s 2ms/step
Clean Classification accuracy: 98.64899974019225
361/361 [==============================] - 1s 2ms/step
Attack Success Rate: 100.0
```

```
model = keras.models.load_model(model_filename)
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 check the clean data

```
x_data, y_data = data_loader(clean_data_filename)
figure = plt.figure(figsize=(10,8))
cols, rows = 5,5
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()
```


```
x_poisoned_data, y_poisoned_data = data_loader(poisoned_data_filename)
figure = plt.figure(figsize=(10,8))
cols, rows = 5,5
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()
```


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

Prune defense

Pruning the model in the following way:

1. The activation of the last pooling layer (pool_3) is checked.
2. The smallest average activation is ALWAYS pruned.
3. For convolution layer (conv_3), there are 60 channels in total and we need to get the index to prune.

```
# 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)
```

```
clean_data_acc = 98.64899974019225
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('pruned_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('pruned_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('pruned_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()
```

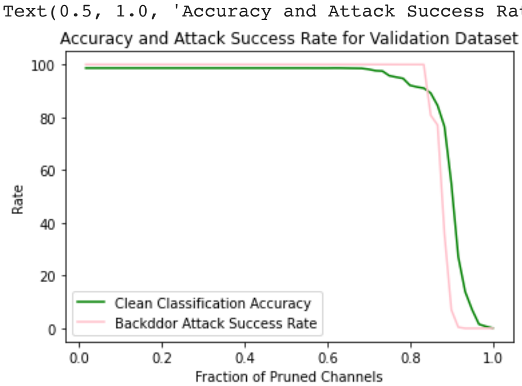
```
The attack success rate is:  99.9913397419243
The pruned channel index is:  16
361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
 78%|████████████   | 47/60 [02:01<00:34,  2.64s/it]
The clean accuracy is:  94.7172425738287
The attack success rate is:  99.9913397419243
The pruned channel index is:  56
361/361 [==============================] - 1s 2ms/step
WARNING:tensorflow:Compiled the loaded model, but the compiled metrics have yet to be built. `model.compile_metrics` will b
The accuracy drops at least 4%, saved the model
361/361 [==============================] - 1s 2ms/step
 80%|████████████   | 48/60 [02:04<00:31,  2.61s/it]
The clean accuracy is:  92.10184463497012
The attack success rate is:  99.9913397419243
The pruned channel index is:  46
361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
```

```
print("Clean Classification Accuracy: ", clean_acc)
print("Backddor Attack Success Rate: ", asrate)
```

```
Clean Classification Accuracy:  [98.64899974019225, 98.64899974019225, 98.64899974019225, 98.64899974019225, 98.6489997401922
Backddor 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, 10
```

```
# Plot Accuracy and Attack Success Rate for Validation Dataset
x_axis = np.arange(1,61)/60
plt.plot(x_axis,clean_acc, color = 'green')
plt.plot(x_axis,asrate, color = 'pink')
plt.legend(['Clean Classification Accuracy','Backddor Attack Success Rate'])
plt.xlabel("Fraction of Pruned Channels")
plt.ylabel("Rate")
plt.title("Accuracy and Attack Success Rate for Validation Dataset")
```

```
Text(0.5, 1.0, 'Accuracy and Attack Success Rate for Validation Dataset')
```




```
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%:  6.980168009006668
```

GoodNets

GoodNets model is the combination of original badnets model and pruned model. The goodNets will output the prediction if the prediction from BadNets model and the one from pruned model are the same.

```
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
```

Evaluation of GoodNets Model

```
test_data_filename = 'data/cl/test.h5'
poisoned_test_data_filename = 'data/bd/bd_test.h5'
test_model_pruned_2_filename = '/content/pruned_2.h5'
test_model_pruned_4_filename = '/content/pruned_4.h5'
test_model_pruned_10_filename = '/content/pruned_10.h5'
```

```
test_model_pruned_2 = keras.models.load_model(test_model_pruned_2_filename)
test_model_pruned_4 = keras.models.load_model(test_model_pruned_4_filename)
test_model_pruned_10 = keras.models.load_model(test_model_pruned_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.
```

```
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)

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)
```

```
G_model_pruned_2 = G(model, test_model_pruned_2)
G_model_pruned_4 = G(model, test_model_pruned_4)
G_model_pruned_10 = G(model, test_model_pruned_10)
```

Evaluation on The Test Dataset

```
# For X={2%,4%,10%}, print out the clean test data classification accuracy and backdoor attack success rate
cl_test_2_label_p = np.argmax(test_model_pruned_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_pruned_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, Backdoor Attack Success Rate:', asr_2)

cl_test_4_label_p = np.argmax(test_model_pruned_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_pruned_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, Backdoor Attack Success Rate:', asr_4)

cl_test_10_label_p = np.argmax(test_model_pruned_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_pruned_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, BackdoorAttack Success Rate:', asr_10)
```

```
401/401 [==============================] - 1s 2ms/step
2% drops model, The Clean Test Data Classification Accuracy: 95.90802805923616
401/401 [==============================] - 1s 2ms/step
2% drops model, Backdoor Attack Success Rate: 100.0
401/401 [==============================] - 1s 2ms/step
4% drops model, The Clean Test Data Classification Accuracy: 92.29150428682775
401/401 [==============================] - 1s 2ms/step
4% drops model, Backdoor Attack Success Rate: 99.98441153546376
401/401 [==============================] - 1s 2ms/step
10% drops model, The Clean Test Data Classification Accuracy: 84.54403741231489
```

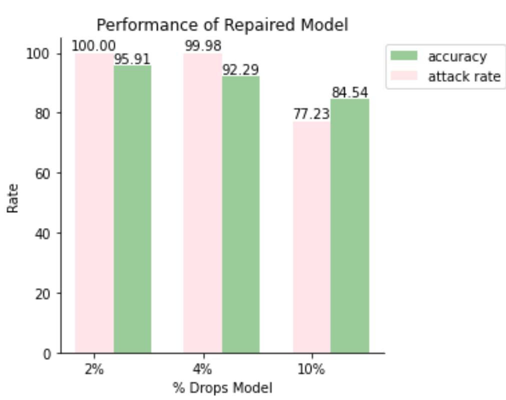
```
401/401 [==============================] - 1s 2ms/step
10% drops model, BackdoorAttack Success Rate: 77.23304754481684
```

Summarization of The Fixed Models

```
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')
```

model	text_acc	attack_rate
repaired_2%	95.908028	100.000000
repaired_4%	92.291504	99.984412
repaired_10%	84.544037	77.233048

```
opacity = 0.4
bar_width = 0.35

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='green', label='Acc
bar2 = plt.bar(range(len(attack_rate)), attack_rate, bar_width, align='center', alpha=opacity, color='pink', label='Attack Rate')

# Add counts above the two bar graphs
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 combine the two models that are the original badnet and the 'fixed' model

```
G_cl_test_2_label_p = G_model_pruned_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_pruned_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, Backdoor Attack Success Rate:', G_asr_2)
```

```
G_cl_test_4_label_p = G_model_pruned_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_pruned_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, Backdoor Attack Success Rate:', G_asr_4)

G_cl_test_10_label_p = G_model_pruned_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_pruned_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, Backdoor Attack Success Rate:', G_asr_10)
```

```
Combined 2% drops model, The Clean Test Data Classification Accuracy: 95.90802805923616
Combined 2% drops model, Backdoor Attack Success Rate: 100.0
Combined 4% drops model, The Clean Test Data Classification Accuracy: 92.29150428682775
Combined 4% drops model, Backdoor Attack Success Rate: 99.98441153546376
Combined 10% drops model, The Clean Test Data Classification Accuracy: 84.54403741231489
Combined 10% drops model, Backdoor Attack Success Rate: 77.23304754481684
```

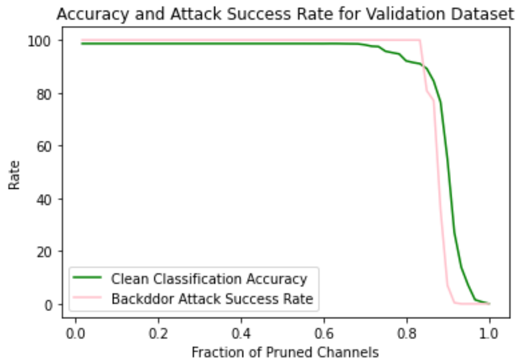
```
G_test_acc = [G_clean_test_2_accuracy, G_clean_test_4_accuracy, G_clean_test_10_accuracy]
G_attack_rate = [G_asr_2, G_asr_4, G_asr_10]
G_data = {
    "G_text_acc": G_test_acc,
    "G_attack_rate": G_attack_rate,
    "G_model": ["G_2%", "G_4%", "G_10%"]
}
G_df = pd.DataFrame(G_data)
G_df.set_index('G_model')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

G_model	G_text_acc	G_attack_rate
G_2%	95.908028	100.000000
G_4%	92.291504	99.984412
G_10%	84.544037	77.233048

```
opacity = 0.4
bar_width = 0.35

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='green', label=
bar2 = plt.bar(range(len(G_attack_rate)),G_attack_rate, bar_width, align='center', alpha=opacity, color='pink', 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 GoodNets Model')
sns.despine()
plt.show()
```

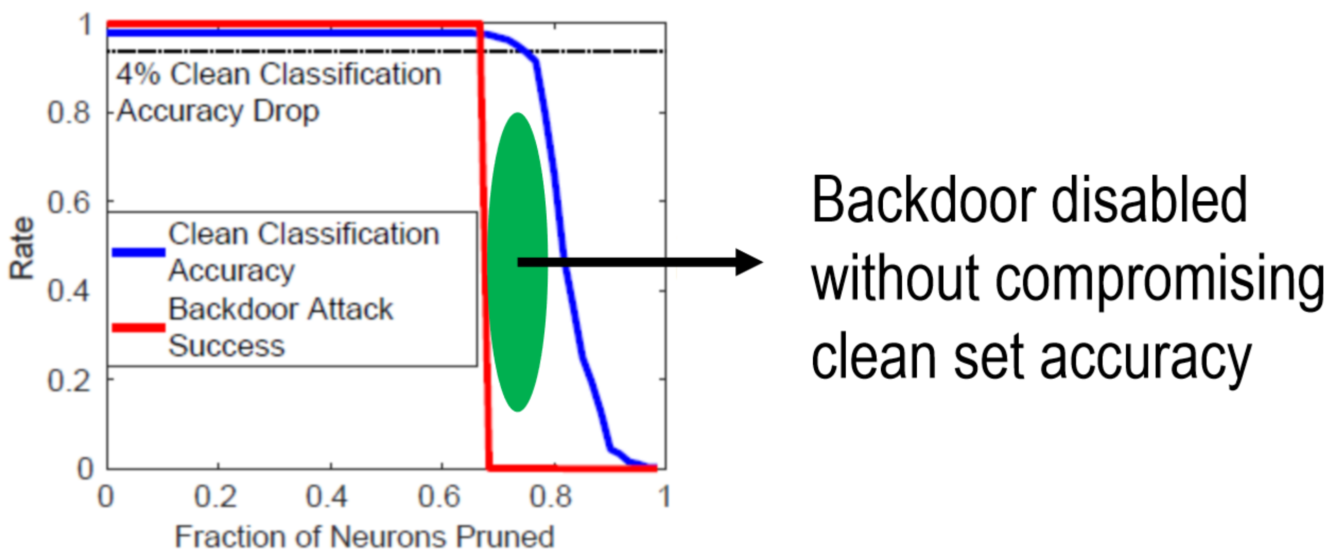
Performance of GoodNets Model

Conclusion



From the start, before pruning the defense, the accuracy is 98.65 and the attack success rate is 100.0. From the evaluation section, we can see that if we prune the channels slightly, the effect is not very obvious. As the number of pruned channels increases, the attack success rate decreases. When we trim a large number of channels, the attack success rate decreases a lot. However, the accuracy rate also decreases a lot. In addition, from the figure above, we can see that there is no large "green space" such as the space in the picture below. That is, the backdoor is enabled at the expense of the accuracy of the clean set. Therefore, I think that the pruning defense does not actually work for this model. This is probably because the attacker (this bd_model) adapts to this defense, i.e., the adaptive attacker introduces sacrificial neurons in the network to disable the pruning defense. This is why we do not see a significant effect of our defense approach.

Example from Lecture Slides:



(a) Baseline Attack (Face)

0 秒 完成时间：17:41