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РТУ МИРЭА

ИКБ направление «Кибербразведка и противодействие угрозам с применением технологий искусственного интеллекта» 10.04.01

Кафедра КБ-4 «Интеллектуальные системы информационной безопасности»

Практическая работа №4

по дисциплине

«Анализ защищенности систем искусственного интеллекта»

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Выполнение работы:

Загружаем пакет art

```
[1] !pip install adversarial-robustness-toolbox

Collecting adversarial-robustness-toolbox
  Downloading adversarial_robustness_toolbox-1.16.0-py3-none-any.whl (1.6 MB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 1.6/1.6 MB 16.4 MB/s eta 0:00:00
Requirement already satisfied: numpy>=1.18.0 in /usr/local/lib/python3.10/dist-packages (from adversarial-robustness-toolbox) (1.23.5)
Requirement already satisfied: scipy>=1.4.1 in /usr/local/lib/python3.10/dist-packages (from adversarial-robustness-toolbox) (1.11.3)
Collecting scikit-learn<1.2.0,>=0.22.2 (from adversarial-robustness-toolbox)
  Downloading scikit_learn-1.1.3-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_64.whl (30.5 MB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 30.5/30.5 MB 53.6 MB/s eta 0:00:00
Requirement already satisfied: six in /usr/local/lib/python3.10/dist-packages (from adversarial-robustness-toolbox) (1.16.0)
Requirement already satisfied: setuptools in /usr/local/lib/python3.10/dist-packages (from adversarial-robustness-toolbox) (67.7.2)
Requirement already satisfied: tqdm in /usr/local/lib/python3.10/dist-packages (from adversarial-robustness-toolbox) (4.66.1)
Requirement already satisfied: joblib>=1.0.0 in /usr/local/lib/python3.10/dist-packages (from scikit-learn<1.2.0,>=0.22.2->adversarial-robustness-toolbox) (1.3.2)
Requirement already satisfied: threadpoolctl>=2.0.0 in /usr/local/lib/python3.10/dist-packages (from scikit-learn<1.2.0,>=0.22.2->adversarial-robustness-toolbox) (3.2.0)
Installing collected packages: scikit-learn, adversarial-robustness-toolbox
  Attempting uninstall: scikit-learn
    Found existing installation: scikit-learn 1.2.2
    Uninstalling scikit-learn-1.2.2:
      Successfully uninstalled scikit-learn-1.2.2
ERROR: pip's dependency resolver does not currently take into account all the packages that are installed. This behaviour is the source of the following dependency conflicts.
bigframes 0.10.0 requires scikit-learn>=1.2.2, but you have scikit-learn 1.1.3 which is incompatible.
Successfully installed adversarial-robustness-toolbox-1.16.0 scikit-learn-1.1.3
```

Загружаем необходимые библиотеки

```
from __future__ import absolute_import, division, print_function, unicode_literals

import os, sys
from os.path import abspath

module_path = os.path.abspath(os.path.join('..'))
if module_path not in sys.path:
  sys.path.append(module_path)

import warnings
warnings.filterwarnings('ignore')

import tensorflow as tf
tf.compat.v1.disable_eager_execution()
tf.get_logger().setLevel('ERROR')

import tensorflow.keras.backend as k
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense, Flatten, Conv2D, MaxPooling2D, Activation, Dropout

import numpy as np
import matplotlib.pyplot as plt

%matplotlib inline
from art.estimators.classification import KerasClassifier
from art.attacks.poisoning import PoisoningAttackBackdoor, PoisoningAttackCleanLabelBackdoor
from art.attacks.poisoning.perturbations import add_pattern_bd
from art.utils import load_mnist, preprocess, to_categorical
from art.defences.trainer import AdversarialTrainerMadryPGD
```

Загружаем датасет

```
[3] (x_raw, y_raw), (x_raw_test, y_raw_test), min_, max_ = load_mnist(raw=True)

    # Случайная выборка
    n_train = np.shape(x_raw)[0]
    num_selection = 10000
    random_selection_indices = np.random.choice(n_train, num_selection)
    x_raw = x_raw[random_selection_indices]
    y_raw = y_raw[random_selection_indices]
```

Выполняем предобработку данных

```
[4]  # Отравленные данные
     percent_poison = .33
     x_train, y_train = preprocess(x_raw, y_raw)
     x_train = np.expand_dims(x_train, axis=3)

     x_test, y_test = preprocess(x_raw_test, y_raw_test)
     x_test = np.expand_dims(x_test, axis=3)

     # Предобработка данных

     n_train = np.shape(y_train)[0]
     shuffled_indices = np.arange(n_train)
     np.random.shuffle(shuffled_indices)
     x_train = x_train[shuffled_indices]
     y_train = y_train[shuffled_indices]
```

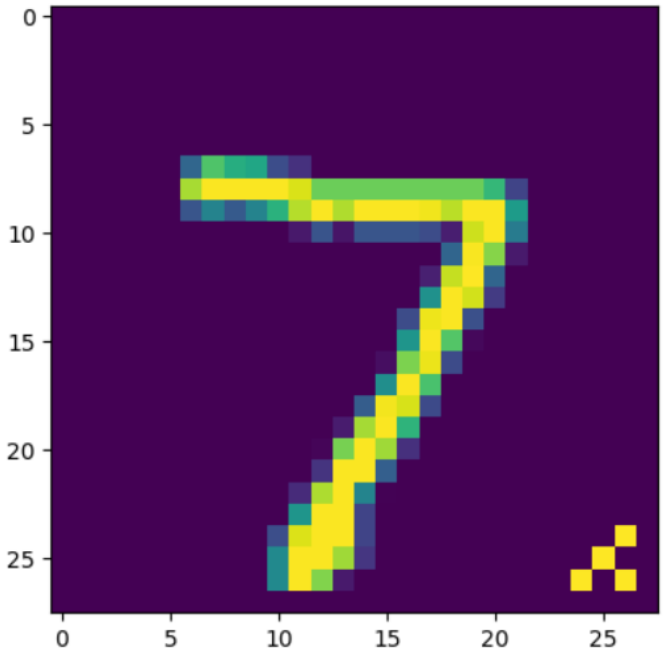
Пишем функцию create_model()

```
[5]  # функция create_model() для создания последовательной модели из 9 слоев
     from tensorflow.keras.models import Sequential
     from tensorflow.keras.layers import Dense, Flatten, Conv2D, MaxPooling2D, Dropout

     def create_model():
         # архитектура модели
         model = Sequential()
         # сверточные слои
         model.add(Conv2D(32, (3, 3), activation='relu', input_shape=(28, 28, 1)))
         model.add(Conv2D(64, (3, 3), activation='relu'))
         # пулинговый слой
         model.add(MaxPooling2D(pool_size=(2, 2)))
         # dropout слой
         model.add(Dropout(0.25))
         # выравнивающий слой
         model.add(Flatten())
         # полносвязные слои
         model.add(Dense(128, activation='relu'))
         model.add(Dropout(0.25))
         model.add(Dense(10, activation='softmax'))

         # компиляция
         model.compile(loss='categorical_crossentropy', optimizer='adam', metrics=['accuracy'])

         return model
```

Создаем атаку

```
[6]  backdoor = PoisoningAttackBackdoor(add_pattern_bd)
     example_target = np.array([0, 0, 0, 0, 0, 0, 0, 0, 0, 1])
     pdata, plabels = backdoor.poison(x_test, y=example_target)
     plt.imshow(pdata[0].squeeze())
```

```
<matplotlib.image.AxesImage at 0x7c79c78b3a00>
```



Определяем целевой класс атаки

```
[7]  targets = to_categorical([9], 10)[0]
```

Создаем модель

```
[8]  model = KerasClassifier(create_model())
     proxy = AdversarialTrainerMadryPGD(KerasClassifier(create_model()), nb_epochs=10, eps=0.15, eps_step=0.001)
     proxy.fit(x_train, y_train)
```

```
Precompute adv samples: 100% 1/1 [00:00<00:00, 20.51it/s]
Adversarial training epochs: 100% 10/10 [22:58<00:00, 134.53s/it]
```

Выполняем атаку

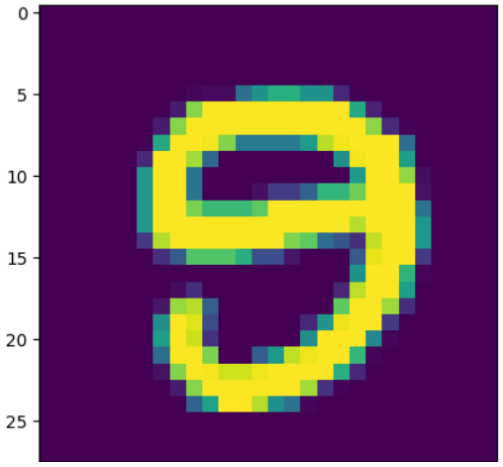
```
[9]  attack = PoisoningAttackCleanLabelBackdoor(backdoor=backdoor, proxy_classifier=proxy.get_classifier(), target=targets,pp_poison=percent_poison, norm=2, eps=5, eps_step=0.1, max_
     pdata, plabels = attack.poison(x_train, y_train)
```

```
PGD - Random Initializations: 100% 1/1 [00:09<00:00, 9.01s/it]
PGD - Random Initializations: 100% 1/1 [00:10<00:00, 10.58s/it]
PGD - Random Initializations: 100% 1/1 [00:10<00:00, 10.60s/it]
PGD - Random Initializations: 100% 1/1 [00:09<00:00, 9.76s/it]
PGD - Random Initializations: 100% 1/1 [00:09<00:00, 9.72s/it]
PGD - Random Initializations: 100% 1/1 [00:10<00:00, 10.60s/it]
PGD - Random Initializations: 100% 1/1 [00:10<00:00, 10.53s/it]
PGD - Random Initializations: 100% 1/1 [00:08<00:00, 8.96s/it]
PGD - Random Initializations: 100% 1/1 [00:10<00:00, 10.60s/it]
PGD - Random Initializations: 100% 1/1 [00:10<00:00, 10.60s/it]
PGD - Random Initializations: 100% 1/1 [00:02<00:00, 2.15s/it]
```

Создаем отравленные примеры данных

```
[10] poisoned = pdata[np.all(plabels == targets, axis=1)]
     poisoned_labels = plabels[np.all(plabels == targets, axis=1)]

     print(len(poisoned))

     idx = 0
     plt.imshow(poisoned[idx].squeeze())
     print(f"Label: {np.argmax(poisoned_labels[idx])}")
```

```
978
Label: 9
```



Обучим модель на отравленных данных

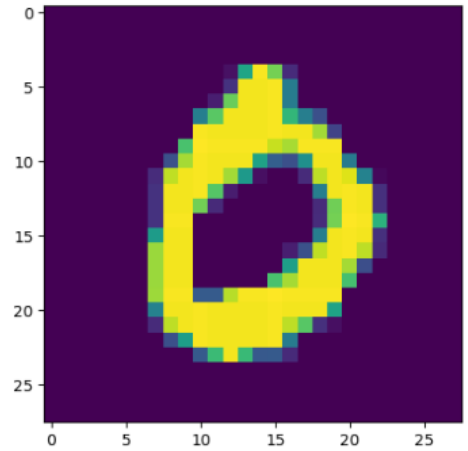
```
[11] model.fit(pdata, plabels, nb_epochs=10)
```

```
Train on 10000 samples
Epoch 1/10
10000/10000 [==============================] - 23s 2ms/sample - loss: 0.5776 - accuracy: 0.8234
Epoch 2/10
10000/10000 [==============================] - 21s 2ms/sample - loss: 0.1763 - accuracy: 0.9463
Epoch 3/10
10000/10000 [==============================] - 23s 2ms/sample - loss: 0.1063 - accuracy: 0.9675
Epoch 4/10
10000/10000 [==============================] - 21s 2ms/sample - loss: 0.0671 - accuracy: 0.9788
Epoch 5/10
10000/10000 [==============================] - 23s 2ms/sample - loss: 0.0515 - accuracy: 0.9851
Epoch 6/10
10000/10000 [==============================] - 21s 2ms/sample - loss: 0.0346 - accuracy: 0.9886
Epoch 7/10
10000/10000 [==============================] - 22s 2ms/sample - loss: 0.0323 - accuracy: 0.9890
Epoch 8/10
10000/10000 [==============================] - 23s 2ms/sample - loss: 0.0226 - accuracy: 0.9927
Epoch 9/10
10000/10000 [==============================] - 21s 2ms/sample - loss: 0.0210 - accuracy: 0.9931
Epoch 10/10
10000/10000 [==============================] - 23s 2ms/sample - loss: 0.0174 - accuracy: 0.9942
```

Осуществим тест на чистой модели

```
[12] clean_preds = np.argmax(model.predict(x_test), axis=1)
     clean_correct = np.sum(clean_preds == np.argmax(y_test, axis=1))
     clean_total = y_test.shape[0]
     clean_acc = clean_correct / clean_total

     print("\nClean test set accuracy: %.2f%%" % (clean_acc * 100))

     # Отразим, как отравленная модель классифицирует чистую модель
     c = 0 # class to display
     i = 0 # image of the class to display
     c_idx = np.where(np.argmax(y_test, 1) == c)[0][i] # index of the image in clean arrays
     plt.imshow(x_test[c_idx].squeeze())
     plt.show()
     clean_label = c
     print("Prediction: " + str(clean_preds[c_idx]))
```

```
Clean test set accuracy: 97.92%
```

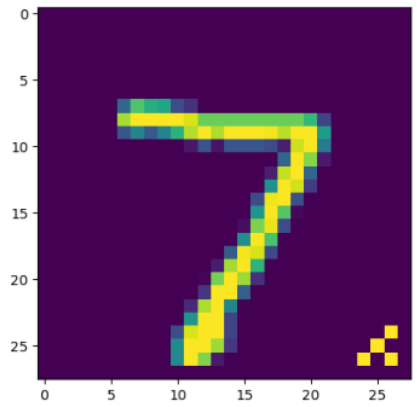



```
Prediction: 0
```

Получаем результаты атаки на модель

```
[13] not_target = np.logical_not(np.all(y_test == targets, axis=1))
     px_test, py_test = backdoor.poison(x_test[not_target], y_test[not_target])
     poison_preds = np.argmax(model.predict(px_test), axis=1)
     poison_correct = np.sum(poison_preds == np.argmax(y_test[not_target],
     axis=1))
     poison_total = poison_preds.shape[0]
     poison_acc = poison_correct / poison_total

     print("\nPoison test set accuracy: %.2f%%" % (poison_acc * 100))

     c = 0 # index to display
     plt.imshow(px_test[c].squeeze())
     plt.show()
     clean_label = c

     print("Prediction: " + str(poison_preds[c]))
```

```
Poison test set accuracy: 1.09%
```




```
Prediction: 9
```