In [ ]:
```
!git clone https://github.com/ewatson2/EEL6812_DeepFool_Project.git
```

```
Cloning into 'EEL6812_DeepFool_Project'...
remote: Enumerating objects: 96, done.
remote: Counting objects:  33% (1/3)
remote: Counting objects:  66% (2/3)
remote: Counting objects: 100% (3/3)
remote: Counting objects: 100% (3/3), done.
remote: Compressing objects: 100% (2/2), done.
remote: Total 96 (delta 2), reused 1 (delta 1), pack-reused 93 (from 1)
Receiving objects: 100% (96/96), 33.99 MiB | 32.47 MiB/s, done.
Resolving deltas: 100% (27/27), done.
```

Сменить директорию исполнения на вновь созданную папку "EEL6812_DeepFool_Project" проекта.

In [ ]:
```
%cd ./EEL6812_DeepFool_Project
```

```
/content/EEL6812_DeepFool_Project/EEL6812_DeepFool_Project
```

Выполнить импорт библиотек

In [ ]:
```
import numpy as np
import json, torch
from torch.utils.data import DataLoader, random_split
from torchvision import datasets, models
from torchvision.transforms import transforms
```

Выполним импорт вспомогательных библиотек из локальных файлов проекта:

In [ ]:
```
from models.project_models import FC_500_150, LeNet_CIFAR, LeNet_MNIST, I
from utils.project_utils import get_clip_bounds, evaluate_attack, displa
```

Установим случайное рандомное значение в виде переменной rand_seed= {"Порядковый номер ученика группы в Гугл-таблице"}, укажем значение для np.random.seed и torch.manual_seed Установить указанное значение для np.random.seed и torch.manual_seed Использовать в качестсве устройства видеокарту (Среды выполнения--> Сменить среду выполнения --> T4 GPU)

In [ ]:
```
rand_seed = 20
np.random.seed(rand_seed)
torch.manual_seed(rand_seed)

use_cuda = torch.cuda.is_available()
device = torch.device('cuda' if use_cuda else 'cpu')
```

Загрузить датасет MNIST с параметрами mnist_mean = 0.5, mnist_std = 0.5, mnist_dim = 28

In [ ]:

```
mnist_mean = 0.5
mnist_std = 0.5
mnist_dim = 28

mnist_min, mnist_max = get_clip_bounds(mnist_mean,
                                       mnist_std,
                                       mnist_dim)
mnist_min = mnist_min.to(device)
mnist_max = mnist_max.to(device)

mnist_tf = transforms.Compose([
    transforms.ToTensor(),
    transforms.Normalize(
        mean=mnist_mean,
        std=mnist_std)])

mnist_tf_train = transforms.Compose([
    transforms.RandomHorizontalFlip(),
    transforms.ToTensor(),
    transforms.Normalize(
        mean=mnist_mean,
        std=mnist_std)])

mnist_tf_inv = transforms.Compose([
    transforms.Normalize(
        mean=0.0,
        std=np.divide(1.0, mnist_std)),
    transforms.Normalize(
        mean=np.multiply(-1.0, mnist_std),
        std=1.0)])

mnist_temp = datasets.MNIST(root='datasets/mnist', train=True,
                            download=True, transform=mnist_tf_train)
mnist_train, mnist_val = random_split(mnist_temp, [50000, 10000])

mnist_test = datasets.MNIST(root='datasets/mnist', train=False,
                            download=True, transform=mnist_tf)

cifar_classes = ['airplane', 'automobile', 'bird', 'cat', 'deer',
                 'dog', 'frog', 'horse', 'ship', 'truck']
```

```
Downloading http://yann.lecun.com/exdb/mnist/train-images-idx3-ubyte.gz
Failed to download (trying next):
HTTP Error 403: Forbidden

Downloading https://ossci-datasets.s3.amazonaws.com/mnist/train-images-idx
3-ubyte.gz
Downloading https://ossci-datasets.s3.amazonaws.com/mnist/train-images-idx
3-ubyte.gz to datasets/mnist/MNIST/raw/train-images-idx3-ubyte.gz
100%|██████████| 9912422/9912422 [00:00<00:00, 54590458.74it/s]
```

```
Extracting datasets/mnist/MNIST/raw/train-images-idx3-ubyte.gz to dataset
s/mnist/MNIST/raw

Downloading http://yann.lecun.com/exdb/mnist/train-labels-idx1-ubyte.gz
Failed to download (trying next):
HTTP Error 403: Forbidden

Downloading https://ossci-datasets.s3.amazonaws.com/mnist/train-labels-idx
1-ubyte.gz
Downloading https://ossci-datasets.s3.amazonaws.com/mnist/train-labels-idx
1-ubyte.gz to datasets/mnist/MNIST/raw/train-labels-idx1-ubyte.gz
100%|██████████| 28881/28881 [00:00<00:00, 1817653.41it/s]
Extracting datasets/mnist/MNIST/raw/train-labels-idx1-ubyte.gz to dataset
s/mnist/MNIST/raw

Downloading http://yann.lecun.com/exdb/mnist/t10k-images-idx3-ubyte.gz
Failed to download (trying next):
HTTP Error 403: Forbidden

Downloading https://ossci-datasets.s3.amazonaws.com/mnist/t10k-images-idx3
-ubyte.gz
Downloading https://ossci-datasets.s3.amazonaws.com/mnist/t10k-images-idx3
-ubyte.gz to datasets/mnist/MNIST/raw/t10k-images-idx3-ubyte.gz
100%|██████████| 1648877/1648877 [00:00<00:00, 11919203.55it/s]
Extracting datasets/mnist/MNIST/raw/t10k-images-idx3-ubyte.gz to datasets/
mnist/MNIST/raw

Downloading http://yann.lecun.com/exdb/mnist/t10k-labels-idx1-ubyte.gz
Failed to download (trying next):
HTTP Error 403: Forbidden

Downloading https://ossci-datasets.s3.amazonaws.com/mnist/t10k-labels-idx1
-ubyte.gz
Downloading https://ossci-datasets.s3.amazonaws.com/mnist/t10k-labels-idx1
-ubyte.gz to datasets/mnist/MNIST/raw/t10k-labels-idx1-ubyte.gz
100%|██████████| 4542/4542 [00:00<00:00, 12541493.59it/s]
Extracting datasets/mnist/MNIST/raw/t10k-labels-idx1-ubyte.gz to datasets/
mnist/MNIST/raw
```

Загрузить датасет CIFAR-10 с параметрами cifar_mean = [0.491, 0.482, 0.447]

cifar_std = [0.202,0.199, 0.201]

cifar_dim = 32

In [ ]:

```python
cifar_mean = [0.491, 0.482, 0.447]
cifar_std = [0.202, 0.199, 0.201]
cifar_dim = 32

cifar_min, cifar_max = get_clip_bounds(cifar_mean,
                                       cifar_std,
                                       cifar_dim)
cifar_min = cifar_min.to(device)
cifar_max = cifar_max.to(device)

cifar_tf = transforms.Compose([
    transforms.ToTensor(),
```

```
    transforms.Normalize(
        mean=cifar_mean,
        std=cifar_std)])

cifar_tf_train = transforms.Compose([
    transforms.RandomCrop(
        size=cifar_dim,
        padding=4),
    transforms.RandomHorizontalFlip(),
    transforms.ToTensor(),
    transforms.Normalize(
        mean=cifar_mean,
        std=cifar_std)])

cifar_tf_inv = transforms.Compose([
    transforms.Normalize(
        mean=[0.0, 0.0, 0.0],
        std=np.divide(1.0, cifar_std)),
    transforms.Normalize(
        mean=np.multiply(-1.0, cifar_mean),
        std=[1.0, 1.0, 1.0])])

cifar_temp = datasets.CIFAR10(root='datasets/cifar-10', train=True,
                              download=True, transform=cifar_tf_train)
cifar_train, cifar_val = random_split(cifar_temp, [40000, 10000])

cifar_test = datasets.CIFAR10(root='datasets/cifar-10', train=False,
                              download=True, transform=cifar_tf)
```

```
Downloading https://www.cs.toronto.edu/~kriz/cifar-10-python.tar.gz to dat
asets/cifar-10/cifar-10-python.tar.gz
100%|██████████| 170498071/170498071 [00:02<00:00, 64300086.41it/s]
Extracting datasets/cifar-10/cifar-10-python.tar.gz to datasets/cifar-10
Files already downloaded and verified
```

Выполнить настройку и загрузку DataLoader batch_size = 64 workers = 4

In [ ]:

```
batch_size = 64
workers = 4

mnist_loader_train = DataLoader(mnist_train, batch_size=batch_size,
                                shuffle=True, num_workers=workers)
mnist_loader_val = DataLoader(mnist_val, batch_size=batch_size,
                              shuffle=False, num_workers=workers)
mnist_loader_test = DataLoader(mnist_test, batch_size=batch_size,
                               shuffle=False, num_workers=workers)

cifar_loader_train = DataLoader(cifar_train, batch_size=batch_size,
                                shuffle=True, num_workers=workers)
cifar_loader_val = DataLoader(cifar_val, batch_size=batch_size,
                              shuffle=False, num_workers=workers)
cifar_loader_test = DataLoader(cifar_test, batch_size=batch_size,
                               shuffle=False, num_workers=workers)
```

```
/usr/local/lib/python3.10/dist-packages/torch/utils/data/dataloader.py:55
7: UserWarning: This DataLoader will create 4 worker processes in total. O
ur suggested max number of worker in current system is 2, which is smaller
than what this DataLoader is going to create. Please be aware that excessi
ve worker creation might get DataLoader running slow or even freeze, lower
the worker number to avoid potential slowness/freeze if necessary.
  warnings.warn(_create_warning_msg(
```

In [ ]:

```
import os
train_model = True

epochs = 50
epochs_nin = 100

lr = 0.004
lr_nin = 0.01
lr_scale = 0.5

momentum = 0.9

print_step = 5

deep_batch_size = 64
deep_num_classes = 10
deep_overshoot = 0.02
deep_max_iters = 50

deep_args = [deep_batch_size, deep_num_classes,
             deep_overshoot, deep_max_iters]

if not os.path.isdir('weights/deepfool'):
    os.makedirs('weights/deepfool', exist_ok=True)

if not os.path.isdir('weights/fgsm'):
    os.makedirs('weights/fgsm', exist_ok=True)
```

Загрузить и оценить стойкость модели LeNet к FGSM и DeepFool атакам

In [ ]:

```
fgsm_eps = 0.6
model = LeNet_MNIST().to(device)
model.load_state_dict(torch.load('weights/clean/mnist_lenet.pth',map_loca
evaluate_attack('mnist_lenet_fgsm.csv',
                'results', device, model, mnist_loader_test,
                mnist_min, mnist_max,fgsm_eps, is_fgsm=True)
print('')

evaluate_attack('mnist_lenet_deepfool.csv', 'results', device, model,
mnist_loader_test, mnist_min, mnist_max, deep_args, is_fgsm=False)
if device.type == 'cuda': torch.cuda.empty_cache()
```

```
FGSM Test Error : 87.89%
FGSM Robustness : 4.58e-01
FGSM Time (All Images) : 0.29 s
FGSM Time (Per Image) : 28.86 us

DeepFool Test Error : 98.74%
DeepFool Robustness : 9.64e-02
DeepFool Time (All Images) : 193.32 s
DeepFool Time (Per Image) : 19.33 ms
```

```
<ipython-input-24-67343b12efb4>:3: FutureWarning: You are using `torch.loa
d` with `weights_only=False` (the current default value), which uses the d
efault pickle module implicitly. It is possible to construct malicious pic
kle data which will execute arbitrary code during unpickling (See https://
github.com/pytorch/pytorch/blob/main/SECURITY.md#untrusted-models for more
details). In a future release, the default value for `weights_only` will b
e flipped to `True`. This limits the functions that could be executed duri
ng unpickling. Arbitrary objects will no longer be allowed to be loaded vi
a this mode unless they are explicitly allowlisted by the user via `torch.
serialization.add_safe_globals`. We recommend you start setting `weights_o
nly=True` for any use case where you don't have full control of the loaded
file. Please open an issue on GitHub for any issues related to this experi
mental feature.
  model.load_state_dict(torch.load('weights/clean/mnist_lenet.pth',map_loc
ation=torch.device('cpu')))
```

Загрузить и оценить стойкость модели FC к FGSM и DeepFool атакам

In [ ]:

```
fgsm_eps = 0.2
model = FC_500_150().to(device)
model.load_state_dict(torch.load('weights/clean/mnist_fc.pth', map_locati

evaluate_attack('mnist_fc_fgsm.csv', 'results', device, model,
                mnist_loader_test, mnist_min, mnist_max, fgsm_eps, is_fgs
print('')

evaluate_attack('mnist_fc_deepfool.csv', 'results', device, model,
mnist_loader_test, mnist_min, mnist_max, deep_args, is_fgsm=False)
if device.type == 'cuda': torch.cuda.empty_cache()
```

```
FGSM Test Error : 87.08%
FGSM Robustness : 1.56e-01
FGSM Time (All Images) : 0.15 s
FGSM Time (Per Image) : 14.99 us

DeepFool Test Error : 97.92%
DeepFool Robustness : 6.78e-02
DeepFool Time (All Images) : 141.81 s
DeepFool Time (Per Image) : 14.18 ms
```

```
<ipython-input-25-ac820cd184c1>:3: FutureWarning: You are using `torch.loa
d` with `weights_only=False` (the current default value), which uses the d
efault pickle module implicitly. It is possible to construct malicious pic
kle data which will execute arbitrary code during unpickling (See https://
github.com/pytorch/pytorch/blob/main/SECURITY.md#untrusted-models for more
details). In a future release, the default value for `weights_only` will b
e flipped to `True`. This limits the functions that could be executed duri
ng unpickling. Arbitrary objects will no longer be allowed to be loaded vi
a this mode unless they are explicitly allowlisted by the user via `torch.
serialization.add_safe_globals`. We recommend you start setting `weights_o
nly=True` for any use case where you don't have full control of the loaded
file. Please open an issue on GitHub for any issues related to this experi
mental feature.
  model.load_state_dict(torch.load('weights/clean/mnist_fc.pth', map_locat
ion=torch.device('cpu')))
```

In [ ]:

```
# Загрузим и оценим стойкость модели LeNet к FGSM и DeepFool атакам на о
fgsm_eps = 0.1
model = LeNet_CIFAR().to(device)
model.load_state_dict(torch.load('weights/clean/cifar_lenet.pth', map_lo

evaluate_attack('cifar_lenet_fgsm.csv', 'results', device, model, cifar_
print('')
evaluate_attack('cifar_lenet_deepfool.csv', 'results', device, model, ci

if device.type == 'cuda': torch.cuda.empty_cache()
```

```
FGSM Test Error : 91.71%
FGSM Robustness : 8.90e-02
FGSM Time (All Images) : 0.40 s
FGSM Time (Per Image) : 40.08 us

DeepFool Test Error : 87.81%
DeepFool Robustness : 1.78e-02
DeepFool Time (All Images) : 73.27 s
DeepFool Time (Per Image) : 7.33 ms
```

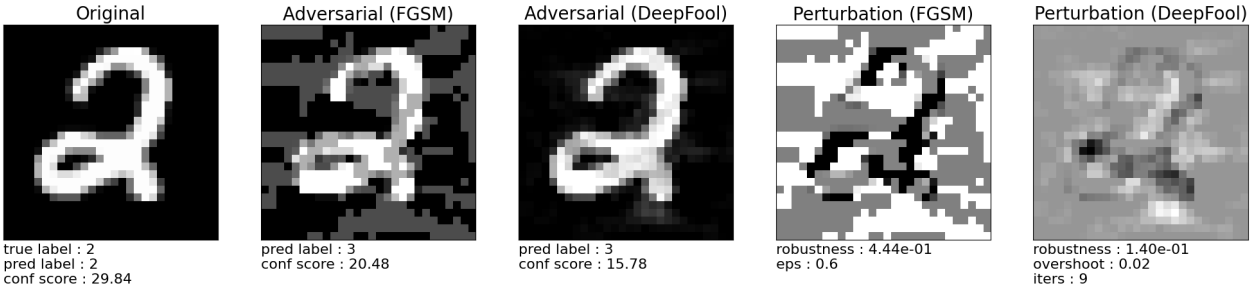
```
<ipython-input-26-08045a679969>:4: FutureWarning: You are using `torch.loa
d` with `weights_only=False` (the current default value), which uses the d
efault pickle module implicitly. It is possible to construct malicious pic
kle data which will execute arbitrary code during unpickling (See https://
github.com/pytorch/pytorch/blob/main/SECURITY.md#untrusted-models for more
details). In a future release, the default value for `weights_only` will b
e flipped to `True`. This limits the functions that could be executed duri
ng unpickling. Arbitrary objects will no longer be allowed to be loaded vi
a this mode unless they are explicitly allowlisted by the user via `torch.
serialization.add_safe_globals`. We recommend you start setting `weights_o
nly=True` for any use case where you don't have full control of the loaded
file. Please open an issue on GitHub for any issues related to this experi
mental feature.
  model.load_state_dict(torch.load('weights/clean/cifar_lenet.pth', map_lo
cation=torch.device('cpu')))
```

In [ ]:

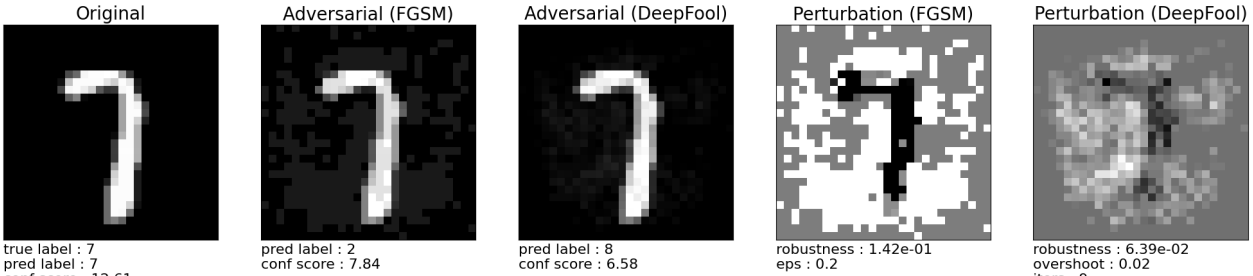
```
# Выполним оценку атакующих примеров для сетей:

# LeNet на датасете MNIST
fgsm_eps = 0.6
model = LeNet_MNIST().to(device)
model.load_state_dict(torch.load('weights/clean/mnist_lenet.pth'))
display_attack(device, model, mnist_test, mnist_tf_inv, mnist_min, mnist_
```

```
                has_labels=False, l2_norm=True, pert_scale=1.0, fig_rows=

if device.type == 'cuda': torch.cuda.empty_cache()

# FCNet на датасете MNIST
fgsm_eps = 0.2
model = FC_500_150().to(device)
model.load_state_dict(torch.load('weights/clean/mnist_fc.pth'))
display_attack(device, model, mnist_test, mnist_tf_inv, mnist_min, mnist_
                has_labels=False, l2_norm=True, pert_scale=1.0, fig_rows=

if device.type == 'cuda': torch.cuda.empty_cache()

# Network-in-Network на датасете CIFAR-10
fgsm_eps = 0.2
model = Net().to(device)
model.load_state_dict(torch.load('weights/clean/cifar_nin.pth'))
display_attack(device, model, cifar_test, cifar_tf_inv, cifar_min, cifar_
                has_labels=False, l2_norm=True, pert_scale=1.0, fig_rows=
                label_map=cifar_classes)

if device.type == 'cuda': torch.cuda.empty_cache()

# LeNet на датасете CIFAR-10
fgsm_eps = 0.1
model = LeNet_CIFAR().to(device)
model.load_state_dict(torch.load('weights/clean/cifar_lenet.pth'))
display_attack(device, model, cifar_test, cifar_tf_inv, cifar_min, cifar_
                has_labels=False, l2_norm=True, pert_scale=1.0, fig_rows=
                label_map=cifar_classes)

if device.type == 'cuda': torch.cuda.empty_cache()
```

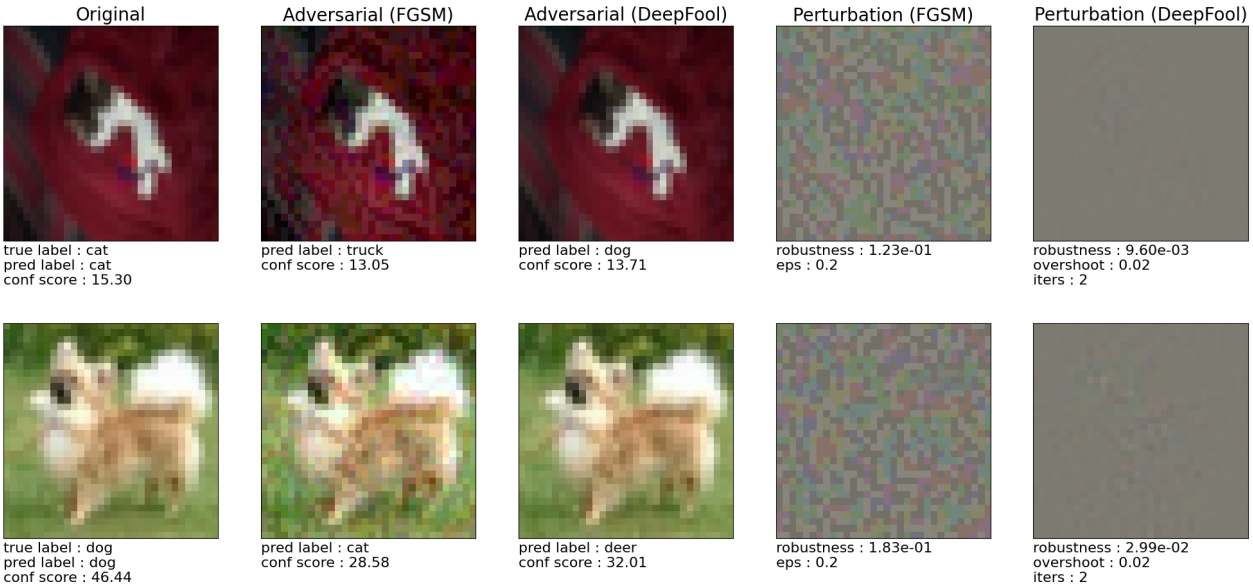
```
<ipython-input-27-d6d3cb22eb2b>:6: FutureWarning: You are using `torch.loa
d` with `weights_only=False` (the current default value), which uses the d
efault pickle module implicitly. It is possible to construct malicious pic
kle data which will execute arbitrary code during unpickling (See https://
github.com/pytorch/pytorch/blob/main/SECURITY.md#untrusted-models for more
details). In a future release, the default value for `weights_only` will b
e flipped to `True`. This limits the functions that could be executed duri
ng unpickling. Arbitrary objects will no longer be allowed to be loaded vi
a this mode unless they are explicitly allowlisted by the user via `torch.
serialization.add_safe_globals`. We recommend you start setting `weights_o
nly=True` for any use case where you don't have full control of the loaded
file. Please open an issue on GitHub for any issues related to this experi
mental feature.
  model.load_state_dict(torch.load('weights/clean/mnist_lenet.pth'))
/usr/local/lib/python3.10/dist-packages/torch/utils/data/dataloader.py:55
7: UserWarning: This DataLoader will create 4 worker processes in total. O
ur suggested max number of worker in current system is 2, which is smaller
than what this DataLoader is going to create. Please be aware that excessi
ve worker creation might get DataLoader running slow or even freeze, lower
the worker number to avoid potential slowness/freeze if necessary.
  warnings.warn(_create_warning_msg(
```



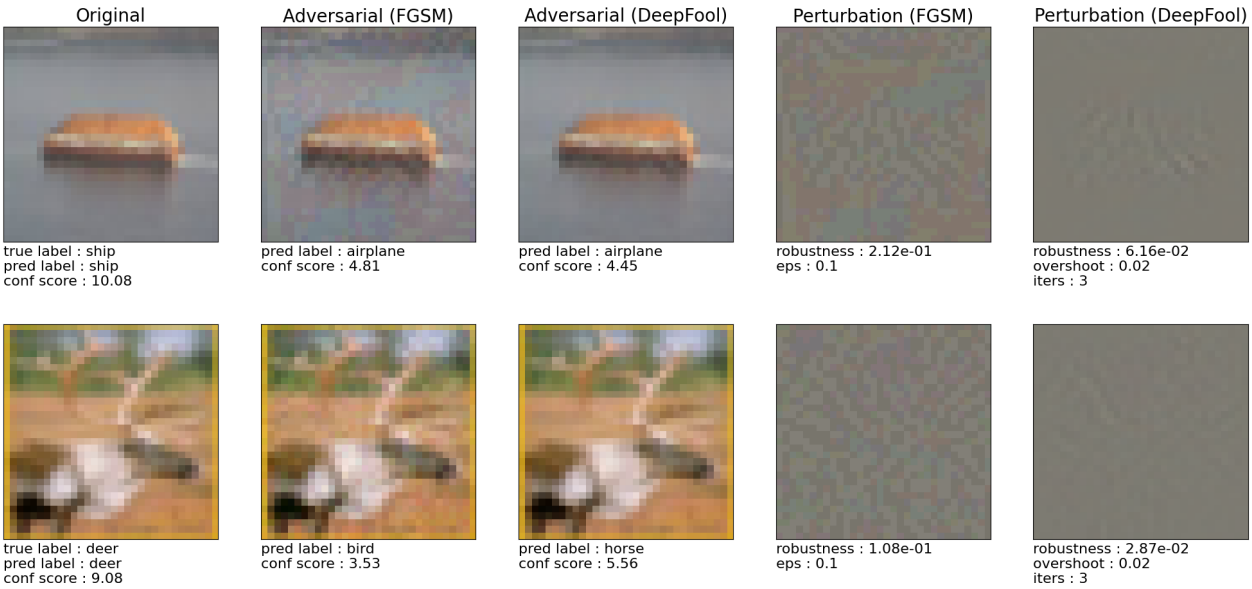

```
<ipython-input-27-d6d3cb22eb2b>:15: FutureWarning: You are using `torch.load` with `weights_only=False` (the current default value), which uses the default pickle module implicitly. It is possible to construct malicious pickle data which will execute arbitrary code during unpickling (See https://github.com/pytorch/pytorch/blob/main/SECURITY.md#untrusted-models for more details). In a future release, the default value for `weights_only` will be flipped to `True`. This limits the functions that could be executed during unpickling. Arbitrary objects will no longer be allowed to be loaded via this mode unless they are explicitly allowlisted by the user via `torch.serialization.add_safe_globals`. We recommend you start setting `weights_only=True` for any use case where you don't have full control of the loaded file. Please open an issue on GitHub for any issues related to this experimental feature.
  model.load_state_dict(torch.load('weights/clean/mnist_fc.pth'))
```



```
<ipython-input-27-d6d3cb22eb2b>:24: FutureWarning: You are using `torch.load` with `weights_only=False` (the current default value), which uses the default pickle module implicitly. It is possible to construct malicious pickle data which will execute arbitrary code during unpickling (See https://github.com/pytorch/pytorch/blob/main/SECURITY.md#untrusted-models for more details). In a future release, the default value for `weights_only` will be flipped to `True`. This limits the functions that could be executed during unpickling. Arbitrary objects will no longer be allowed to be loaded via this mode unless they are explicitly allowlisted by the user via `torch.serialization.add_safe_globals`. We recommend you start setting `weights_only=True` for any use case where you don't have full control of the loaded file. Please open an issue on GitHub for any issues related to this experimental feature.
  model.load_state_dict(torch.load('weights/clean/cifar_nin.pth'))
```




```
<ipython-input-27-d6d3cb22eb2b>:34: FutureWarning: You are using `torch.load` with `weights_only=False` (the current default value), which uses the default pickle module implicitly. It is possible to construct malicious pickle data which will execute arbitrary code during unpickling (See https://github.com/pytorch/pytorch/blob/main/SECURITY.md#untrusted-models for more details). In a future release, the default value for `weights_only` will be flipped to `True`. This limits the functions that could be executed during unpickling. Arbitrary objects will no longer be allowed to be loaded via this mode unless they are explicitly allowlisted by the user via `torch.serialization.add_safe_globals`. We recommend you start setting `weights_only=True` for any use case where you don't have full control of the loaded file. Please open an issue on GitHub for any issues related to this experimental feature.
  model.load_state_dict(torch.load('weights/clean/cifar_lenet.pth'))
```



In [ ]:

```
# Создадим список со значениями eps для FGSM атаки, которые мы хотим исс
fgsm_eps_list = [0.001, 0.02, 0.5, 0.9, 10]

# Создадим цикл для перебора различных значений eps
for fgsm_eps in fgsm_eps_list:
    print(f"Evaluating FGSM Attack with eps={fgsm_eps}...")

    # FC LeNet на датасете MNIST
    model = FC_500_150().to(device)
    model.load_state_dict(torch.load('weights/clean/mnist_fc.pth'))
    evaluate_attack(f'mnist_fc_fgsm_eps{fgsm_eps}.csv', 'results', device

    # NiN LeNet на датасете CIFAR
    model = Net().to(device)
    model.load_state_dict(torch.load('weights/clean/cifar_nin.pth'))
    evaluate_attack(f'cifar_nin_fgsm_eps{fgsm_eps}.csv', 'results', devi

    if device.type == 'cuda': torch.cuda.empty_cache()
```

```
Evaluating FGSM Attack with eps=0.001...
<ipython-input-28-06003cd2da7b>:10: FutureWarning: You are using `torch.lo
ad` with `weights_only=False` (the current default value), which uses the
default pickle module implicitly. It is possible to construct malicious pi
ckle data which will execute arbitrary code during unpickling (See http
s://github.com/pytorch/pytorch/blob/main/SECURITY.md#untrusted-models for
more details). In a future release, the default value for `weights_only` w
ill be flipped to `True`. This limits the functions that could be executed
during unpickling. Arbitrary objects will no longer be allowed to be loade
d via this mode unless they are explicitly allowlisted by the user via `to
rch.serialization.add_safe_globals`. We recommend you start setting `weigh
ts_only=True` for any use case where you don't have full control of the lo
aded file. Please open an issue on GitHub for any issues related to this e
xperimental feature.
  model.load_state_dict(torch.load('weights/clean/mnist_fc.pth'))
/usr/local/lib/python3.10/dist-packages/torch/utils/data/dataloader.py:55
7: UserWarning: This DataLoader will create 4 worker processes in total. O
ur suggested max number of worker in current system is 2, which is smaller
than what this DataLoader is going to create. Please be aware that excessi
ve worker creation might get DataLoader running slow or even freeze, lower
the worker number to avoid potential slowness/freeze if necessary.
  warnings.warn(_create_warning_msg(
```

```
FGSM Batches Complete : (157 / 157)
FGSM Test Error : 3.07%
FGSM Robustness : 8.08e-04
FGSM Time (All Images) : 0.68 s
FGSM Time (Per Image) : 68.33 us
```

```
<ipython-input-28-06003cd2da7b>:15: FutureWarning: You are using `torch.lo
ad` with `weights_only=False` (the current default value), which uses the
default pickle module implicitly. It is possible to construct malicious pi
ckle data which will execute arbitrary code during unpickling (See http
s://github.com/pytorch/pytorch/blob/main/SECURITY.md#untrusted-models for
more details). In a future release, the default value for `weights_only` w
ill be flipped to `True`. This limits the functions that could be executed
during unpickling. Arbitrary objects will no longer be allowed to be loade
d via this mode unless they are explicitly allowlisted by the user via `to
rch.serialization.add_safe_globals`. We recommend you start setting `weigh
ts_only=True` for any use case where you don't have full control of the lo
aded file. Please open an issue on GitHub for any issues related to this e
xperimental feature.
  model.load_state_dict(torch.load('weights/clean/cifar_nin.pth'))
/usr/local/lib/python3.10/dist-packages/torch/utils/data/dataloader.py:55
7: UserWarning: This DataLoader will create 4 worker processes in total. O
ur suggested max number of worker in current system is 2, which is smaller
than what this DataLoader is going to create. Please be aware that excessi
ve worker creation might get DataLoader running slow or even freeze, lower
the worker number to avoid potential slowness/freeze if necessary.
  warnings.warn(_create_warning_msg(
```

```
FGSM Batches Complete : (157 / 157)
FGSM Test Error : 10.12%
FGSM Robustness : 8.92e-04
FGSM Time (All Images) : 1.14 s
FGSM Time (Per Image) : 113.95 us
Evaluating FGSM Attack with eps=0.02...
```

```
<ipython-input-28-06003cd2da7b>:10: FutureWarning: You are using `torch.lo
ad` with `weights_only=False` (the current default value), which uses the
default pickle module implicitly. It is possible to construct malicious pi
ckle data which will execute arbitrary code during unpickling (See http
s://github.com/pytorch/pytorch/blob/main/SECURITY.md#untrusted-models for
more details). In a future release, the default value for `weights_only` w
ill be flipped to `True`. This limits the functions that could be executed
during unpickling. Arbitrary objects will no longer be allowed to be loade
d via this mode unless they are explicitly allowlisted by the user via `to
rch.serialization.add_safe_globals`. We recommend you start setting `weigh
ts_only=True` for any use case where you don't have full control of the lo
aded file. Please open an issue on GitHub for any issues related to this e
xperimental feature.
  model.load_state_dict(torch.load('weights/clean/mnist_fc.pth'))
/usr/local/lib/python3.10/dist-packages/torch/utils/data/dataloader.py:55
7: UserWarning: This DataLoader will create 4 worker processes in total. O
ur suggested max number of worker in current system is 2, which is smaller
than what this DataLoader is going to create. Please be aware that excessi
ve worker creation might get DataLoader running slow or even freeze, lower
the worker number to avoid potential slowness/freeze if necessary.
  warnings.warn(_create_warning_msg(
```

```
FGSM Batches Complete : (157 / 157)
FGSM Test Error : 5.54%
FGSM Robustness : 1.60e-02
FGSM Time (All Images) : 0.54 s
FGSM Time (Per Image) : 53.76 us
```

```
<ipython-input-28-06003cd2da7b>:15: FutureWarning: You are using `torch.lo
ad` with `weights_only=False` (the current default value), which uses the
default pickle module implicitly. It is possible to construct malicious pi
ckle data which will execute arbitrary code during unpickling (See http
s://github.com/pytorch/pytorch/blob/main/SECURITY.md#untrusted-models for
more details). In a future release, the default value for `weights_only` w
ill be flipped to `True`. This limits the functions that could be executed
during unpickling. Arbitrary objects will no longer be allowed to be loade
d via this mode unless they are explicitly allowlisted by the user via `to
rch.serialization.add_safe_globals`. We recommend you start setting `weigh
ts_only=True` for any use case where you don't have full control of the lo
aded file. Please open an issue on GitHub for any issues related to this e
xperimental feature.
  model.load_state_dict(torch.load('weights/clean/cifar_nin.pth'))
/usr/local/lib/python3.10/dist-packages/torch/utils/data/dataloader.py:55
7: UserWarning: This DataLoader will create 4 worker processes in total. O
ur suggested max number of worker in current system is 2, which is smaller
than what this DataLoader is going to create. Please be aware that excessi
ve worker creation might get DataLoader running slow or even freeze, lower
the worker number to avoid potential slowness/freeze if necessary.
  warnings.warn(_create_warning_msg(
FGSM Batches Complete : (157 / 157)
FGSM Test Error : 30.76%
FGSM Robustness : 1.78e-02
FGSM Time (All Images) : 1.48 s
FGSM Time (Per Image) : 148.19 us
Evaluating FGSM Attack with eps=0.5...
<ipython-input-28-06003cd2da7b>:10: FutureWarning: You are using `torch.lo
ad` with `weights_only=False` (the current default value), which uses the
default pickle module implicitly. It is possible to construct malicious pi
ckle data which will execute arbitrary code during unpickling (See http
s://github.com/pytorch/pytorch/blob/main/SECURITY.md#untrusted-models for
more details). In a future release, the default value for `weights_only` w
ill be flipped to `True`. This limits the functions that could be executed
during unpickling. Arbitrary objects will no longer be allowed to be loade
d via this mode unless they are explicitly allowlisted by the user via `to
rch.serialization.add_safe_globals`. We recommend you start setting `weigh
ts_only=True` for any use case where you don't have full control of the lo
aded file. Please open an issue on GitHub for any issues related to this e
xperimental feature.
  model.load_state_dict(torch.load('weights/clean/mnist_fc.pth'))
/usr/local/lib/python3.10/dist-packages/torch/utils/data/dataloader.py:55
7: UserWarning: This DataLoader will create 4 worker processes in total. O
ur suggested max number of worker in current system is 2, which is smaller
than what this DataLoader is going to create. Please be aware that excessi
ve worker creation might get DataLoader running slow or even freeze, lower
the worker number to avoid potential slowness/freeze if necessary.
  warnings.warn(_create_warning_msg(
FGSM Batches Complete : (157 / 157)
FGSM Test Error : 99.21%
FGSM Robustness : 3.86e-01
FGSM Time (All Images) : 0.50 s
FGSM Time (Per Image) : 49.61 us
```

```
<ipython-input-28-06003cd2da7b>:15: FutureWarning: You are using `torch.lo
ad` with `weights_only=False` (the current default value), which uses the
default pickle module implicitly. It is possible to construct malicious pi
ckle data which will execute arbitrary code during unpickling (See http
s://github.com/pytorch/pytorch/blob/main/SECURITY.md#untrusted-models for
more details). In a future release, the default value for `weights_only` w
ill be flipped to `True`. This limits the functions that could be executed
during unpickling. Arbitrary objects will no longer be allowed to be loade
d via this mode unless they are explicitly allowlisted by the user via `to
rch.serialization.add_safe_globals`. We recommend you start setting `weigh
ts_only=True` for any use case where you don't have full control of the lo
aded file. Please open an issue on GitHub for any issues related to this e
xperimental feature.
  model.load_state_dict(torch.load('weights/clean/cifar_nin.pth'))
/usr/local/lib/python3.10/dist-packages/torch/utils/data/dataloader.py:55
7: UserWarning: This DataLoader will create 4 worker processes in total. O
ur suggested max number of worker in current system is 2, which is smaller
than what this DataLoader is going to create. Please be aware that excessi
ve worker creation might get DataLoader running slow or even freeze, lower
the worker number to avoid potential slowness/freeze if necessary.
  warnings.warn(_create_warning_msg(
FGSM Batches Complete : (157 / 157)
FGSM Test Error : 82.67%
FGSM Robustness : 4.40e-01
FGSM Time (All Images) : 1.10 s
FGSM Time (Per Image) : 109.73 us
Evaluating FGSM Attack with eps=0.9...
<ipython-input-28-06003cd2da7b>:10: FutureWarning: You are using `torch.lo
ad` with `weights_only=False` (the current default value), which uses the
default pickle module implicitly. It is possible to construct malicious pi
ckle data which will execute arbitrary code during unpickling (See http
s://github.com/pytorch/pytorch/blob/main/SECURITY.md#untrusted-models for
more details). In a future release, the default value for `weights_only` w
ill be flipped to `True`. This limits the functions that could be executed
during unpickling. Arbitrary objects will no longer be allowed to be loade
d via this mode unless they are explicitly allowlisted by the user via `to
rch.serialization.add_safe_globals`. We recommend you start setting `weigh
ts_only=True` for any use case where you don't have full control of the lo
aded file. Please open an issue on GitHub for any issues related to this e
xperimental feature.
  model.load_state_dict(torch.load('weights/clean/mnist_fc.pth'))
/usr/local/lib/python3.10/dist-packages/torch/utils/data/dataloader.py:55
7: UserWarning: This DataLoader will create 4 worker processes in total. O
ur suggested max number of worker in current system is 2, which is smaller
than what this DataLoader is going to create. Please be aware that excessi
ve worker creation might get DataLoader running slow or even freeze, lower
the worker number to avoid potential slowness/freeze if necessary.
  warnings.warn(_create_warning_msg(
FGSM Batches Complete : (157 / 157)
FGSM Test Error : 99.87%
FGSM Robustness : 6.86e-01
FGSM Time (All Images) : 0.74 s
FGSM Time (Per Image) : 74.45 us
```

```
<ipython-input-28-06003cd2da7b>:15: FutureWarning: You are using `torch.lo
ad` with `weights_only=False` (the current default value), which uses the
default pickle module implicitly. It is possible to construct malicious pi
ckle data which will execute arbitrary code during unpickling (See http
s://github.com/pytorch/pytorch/blob/main/SECURITY.md#untrusted-models for
more details). In a future release, the default value for `weights_only` w
ill be flipped to `True`. This limits the functions that could be executed
during unpickling. Arbitrary objects will no longer be allowed to be loade
d via this mode unless they are explicitly allowlisted by the user via `to
rch.serialization.add_safe_globals`. We recommend you start setting `weigh
ts_only=True` for any use case where you don't have full control of the lo
aded file. Please open an issue on GitHub for any issues related to this e
xperimental feature.
  model.load_state_dict(torch.load('weights/clean/cifar_nin.pth'))
/usr/local/lib/python3.10/dist-packages/torch/utils/data/dataloader.py:55
7: UserWarning: This DataLoader will create 4 worker processes in total. O
ur suggested max number of worker in current system is 2, which is smaller
than what this DataLoader is going to create. Please be aware that excessi
ve worker creation might get DataLoader running slow or even freeze, lower
the worker number to avoid potential slowness/freeze if necessary.
  warnings.warn(_create_warning_msg(
FGSM Batches Complete : (157 / 157)
FGSM Test Error : 84.62%
FGSM Robustness : 7.79e-01
FGSM Time (All Images) : 1.13 s
FGSM Time (Per Image) : 113.22 us
Evaluating FGSM Attack with eps=10...
<ipython-input-28-06003cd2da7b>:10: FutureWarning: You are using `torch.lo
ad` with `weights_only=False` (the current default value), which uses the
default pickle module implicitly. It is possible to construct malicious pi
ckle data which will execute arbitrary code during unpickling (See http
s://github.com/pytorch/pytorch/blob/main/SECURITY.md#untrusted-models for
more details). In a future release, the default value for `weights_only` w
ill be flipped to `True`. This limits the functions that could be executed
during unpickling. Arbitrary objects will no longer be allowed to be loade
d via this mode unless they are explicitly allowlisted by the user via `to
rch.serialization.add_safe_globals`. We recommend you start setting `weigh
ts_only=True` for any use case where you don't have full control of the lo
aded file. Please open an issue on GitHub for any issues related to this e
xperimental feature.
  model.load_state_dict(torch.load('weights/clean/mnist_fc.pth'))
/usr/local/lib/python3.10/dist-packages/torch/utils/data/dataloader.py:55
7: UserWarning: This DataLoader will create 4 worker processes in total. O
ur suggested max number of worker in current system is 2, which is smaller
than what this DataLoader is going to create. Please be aware that excessi
ve worker creation might get DataLoader running slow or even freeze, lower
the worker number to avoid potential slowness/freeze if necessary.
  warnings.warn(_create_warning_msg(
FGSM Batches Complete : (157 / 157)
FGSM Test Error : 99.87%
FGSM Robustness : 1.47e+00
FGSM Time (All Images) : 0.50 s
FGSM Time (Per Image) : 50.00 us
```

```
<ipython-input-28-06003cd2da7b>:15: FutureWarning: You are using `torch.lo
ad` with `weights_only=False` (the current default value), which uses the
default pickle module implicitly. It is possible to construct malicious pi
ckle data which will execute arbitrary code during unpickling (See http
s://github.com/pytorch/pytorch/blob/main/SECURITY.md#untrusted-models for
more details). In a future release, the default value for `weights_only` w
ill be flipped to `True`. This limits the functions that could be executed
during unpickling. Arbitrary objects will no longer be allowed to be loade
d via this mode unless they are explicitly allowlisted by the user via `to
rch.serialization.add_safe_globals`. We recommend you start setting `weigh
ts_only=True` for any use case where you don't have full control of the lo
aded file. Please open an issue on GitHub for any issues related to this e
xperimental feature.
  model.load_state_dict(torch.load('weights/clean/cifar_nin.pth'))
/usr/local/lib/python3.10/dist-packages/torch/utils/data/dataloader.py:55
7: UserWarning: This DataLoader will create 4 worker processes in total. O
ur suggested max number of worker in current system is 2, which is smaller
than what this DataLoader is going to create. Please be aware that excessi
ve worker creation might get DataLoader running slow or even freeze, lower
the worker number to avoid potential slowness/freeze if necessary.
  warnings.warn(_create_warning_msg(
FGSM Batches Complete : (157 / 157)
FGSM Test Error : 87.50%
FGSM Robustness : 2.46e+00
FGSM Time (All Images) : 1.48 s
FGSM Time (Per Image) : 147.86 us
```

Отразим выявленные закономерности для сети FC LeNet:

- при маленьких значениях fgsm_eps, например, fgsm_eps=0.001 и fgsm_eps=0.02, ошибка классификации (FGSM Test Error) остаётся низкой, и сеть остаётся относительно устойчивой к атакам;
- ошибка классификации начинает расти при fgsm_eps=0.5 и fgsm_eps=0.9 и достигает высоких значений, что свидетельствует о нарушении стойкости сети к атакам;
- при очень большом значении (fgsm_eps=10) ошибка классификации также высока, и сеть становится непригодной для задач классификации из-за большого искажения входных данных. Сеть NiN LeNet также начинает демонстрировать увеличение ошибки классификации с ростом параметра fgsm_eps (при fgsm_eps=0.001 и fgsm_eps=0.02 ошибка остаётся низкой, но при fgsm_eps=0.5, fgsm_eps=0.9 и fgsm_eps=10 ошибка резко увеличивается). Визуализируем описанные закономерности для сетей, участвовавших в эксперименте (рис. 1)

Заключение

В результате выполнения лабораторной работы было выявлено, что маленькие значения fgsm_eps сохраняют стойкость сетей к атакам, и ошибки классификации остаются низкими. При увеличении fgsm_eps сети становятся более уязвимыми к атакам и допускают больше ошибок классификации. Для сети FC LeNet на датасете MNIST и для сети NiN LeNEt на датасете CIFAR не наблюдается отсутствие влияния параметра fgsm_ eps. Наоборот, параметр

fgsm_ eps оказывает существенное влияние на стойкость сетей к атакам.