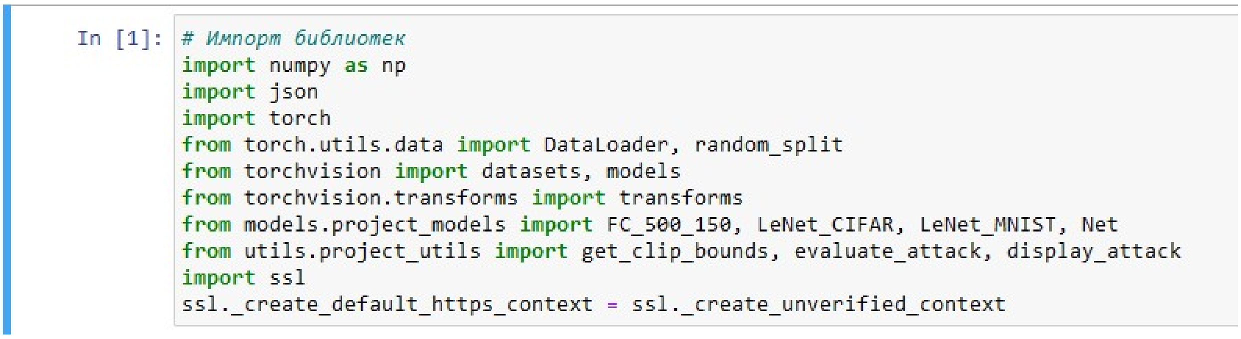
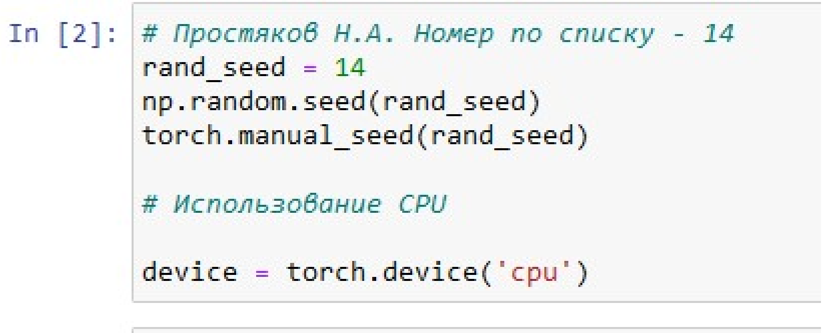


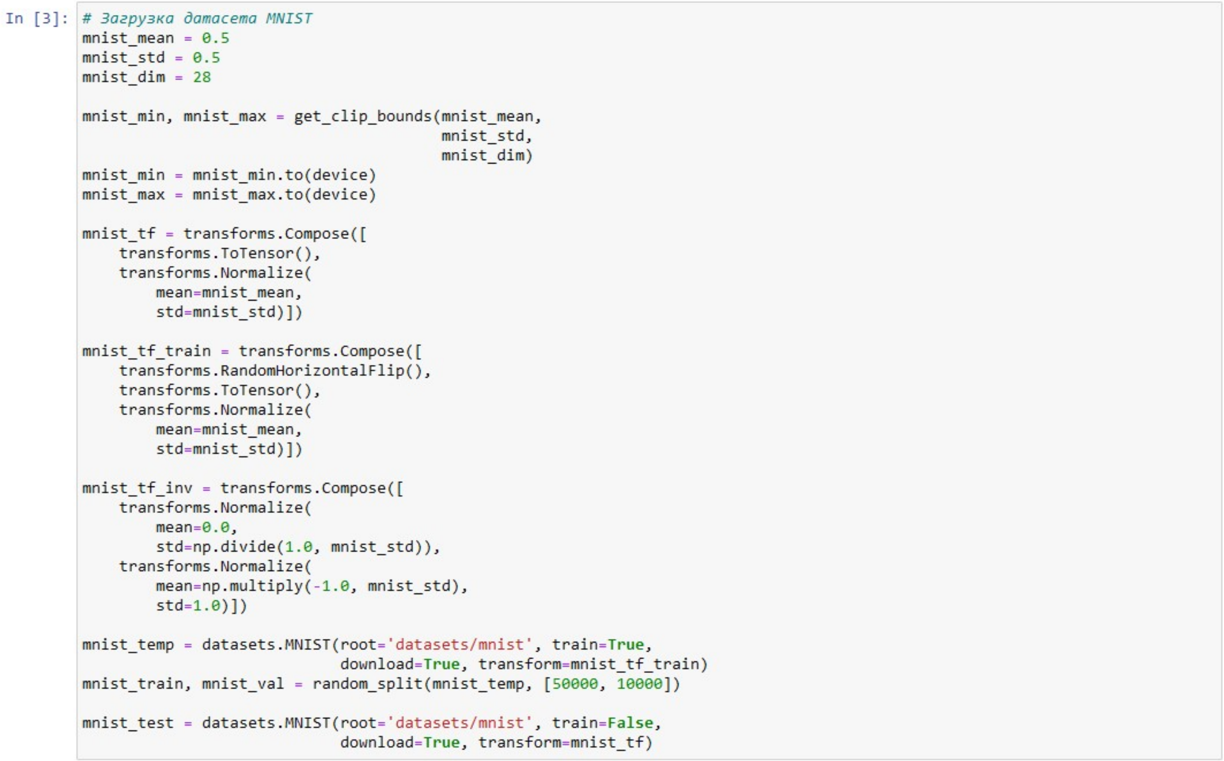
```
In [1]: # Импорт библиотек
        import numpy as np
        import json
        import torch
        from torch.utils.data import DataLoader, random_split
        from torchvision import datasets, models
        from torchvision.transforms import transforms
        from models.project_models import FC_500_150, LeNet_CIFAR, LeNet_MNIST, Net
        from utils.project_utils import get_clip_bounds, evaluate_attack, display_attack
        import ssl
        ssl._create_default_https_context = ssl._create_unverified_context
```

Рисунок 1. – Импорт библиотек



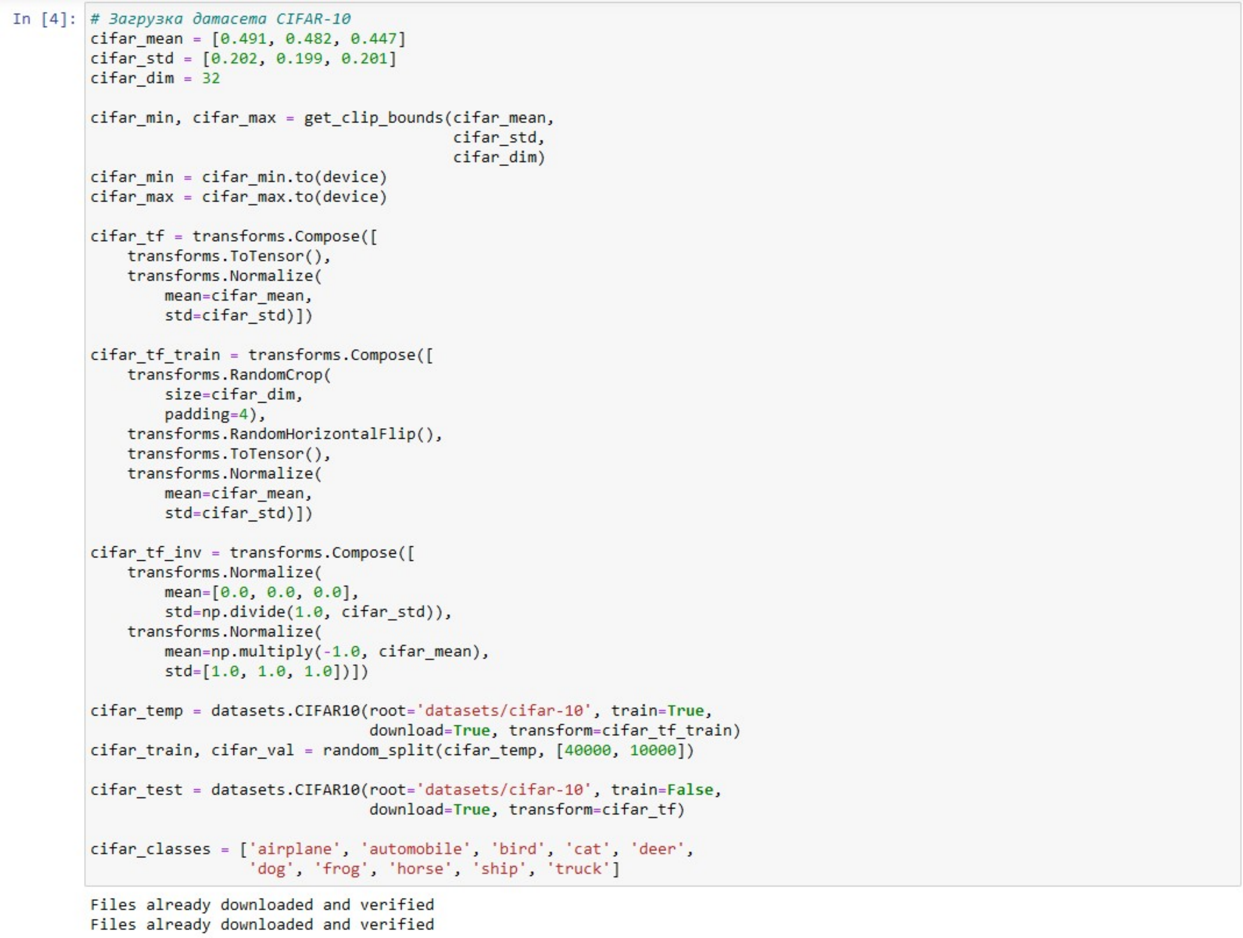
```
In [2]: # Простяков Н.А. Номер по списку - 14
        rand_seed = 14
        np.random.seed(rand_seed)
        torch.manual_seed(rand_seed)

        # Использование CPU

        device = torch.device('cpu')
```

Рисунок 2. – rand_seed



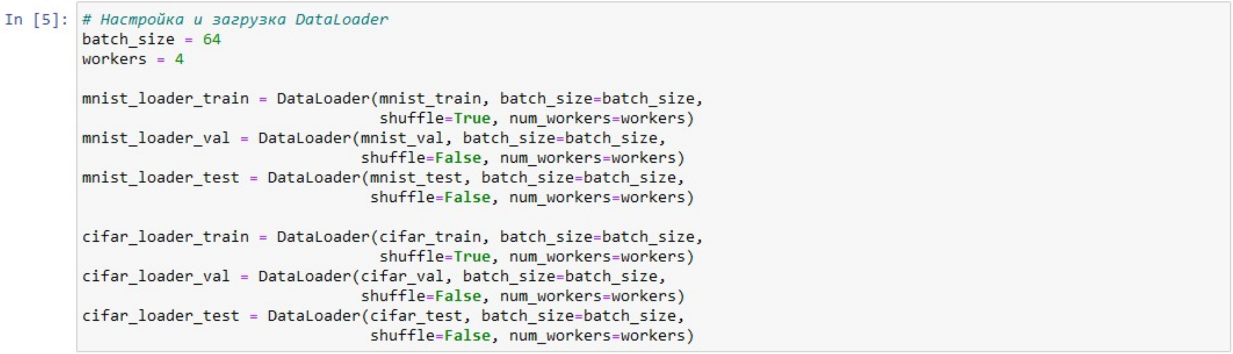
```
In [3]: # Загрузка датасета MNIST
        mnist_mean = 0.5
        mnist_std = 0.5
        mnist_dim = 28

        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)
```

Рисунок 3. – Загрузка датасета MNIST



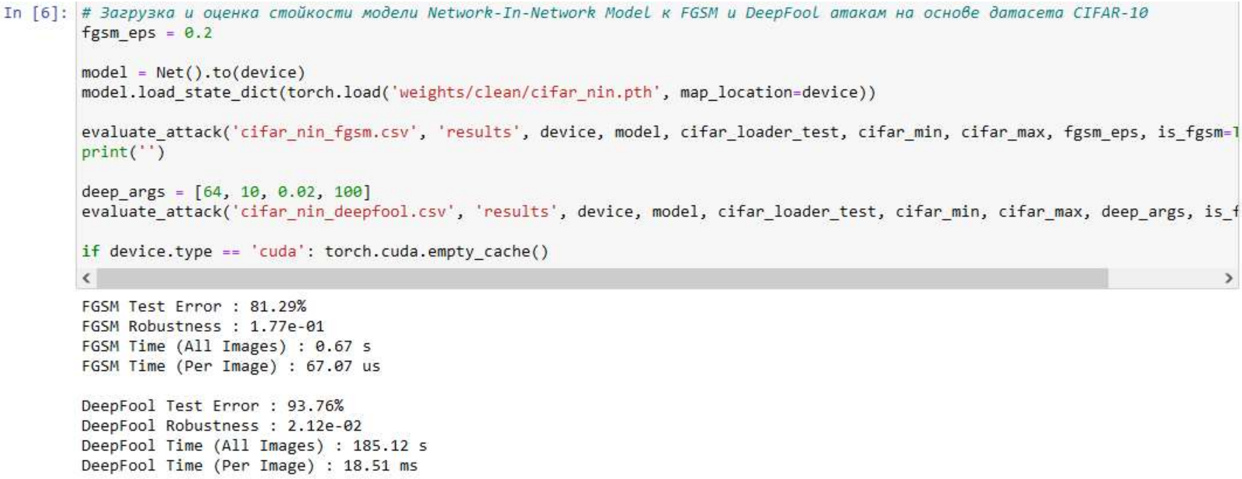
```
In [4]: # Загрузка датасета CIFAR-10
        cifar_mean = [0.491, 0.482, 0.447]
        cifar_std = [0.202, 0.199, 0.201]
        cifar_dim = 32

        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)

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

        Files already downloaded and verified
        Files already downloaded and verified
```

Рисунок 4. – Загрузка датасета CIFAR-10



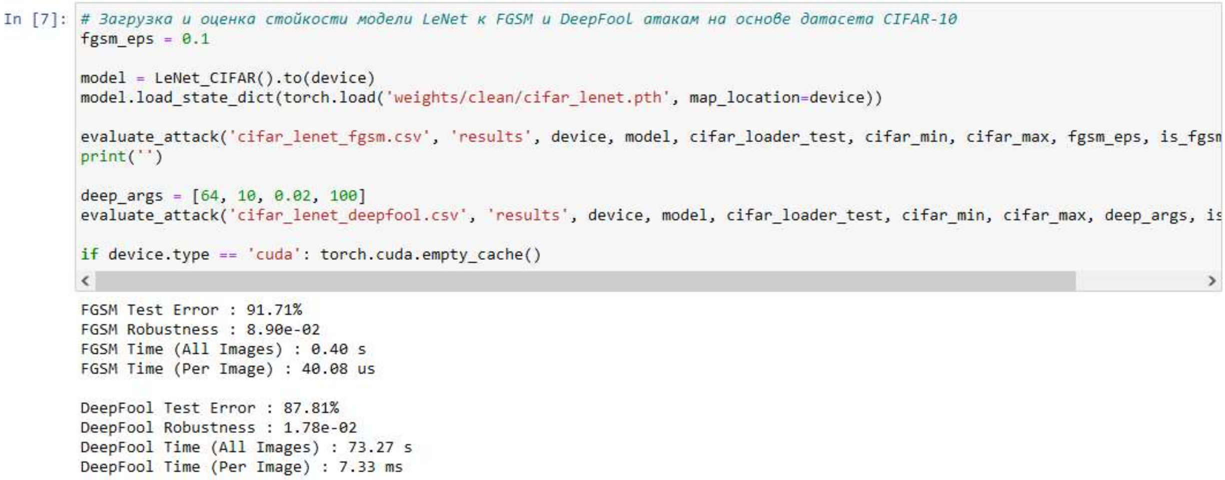
```
In [5]: # Настройка и загрузка DataLoader
        batch_size = 64
        workers = 4

        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)
```

Рисунок 5. – Загрузка и настройка DataLoader



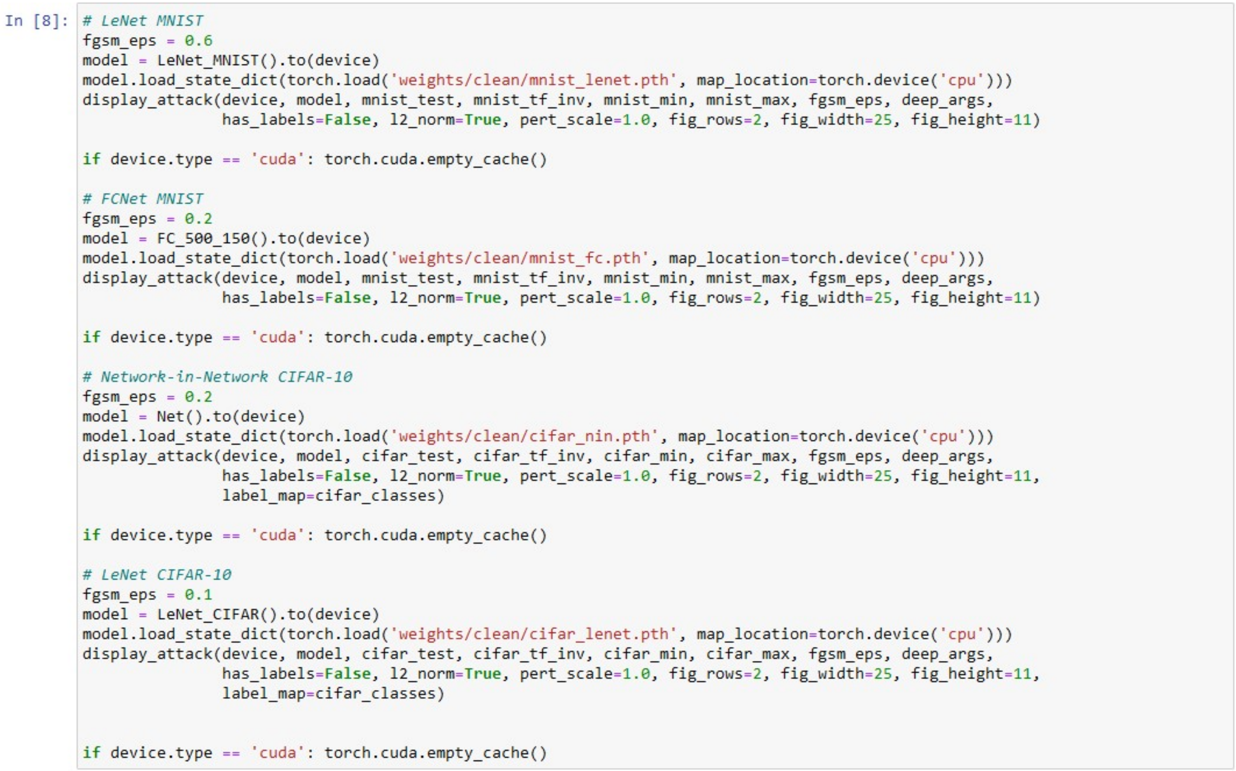
```
In [6]: # Загрузка и оценка стойкости модели Network-In-Network Model к FGSM и DeepFool атакам на основе датасета CIFAR-10
        fgsm_eps = 0.2

        model = Net().to(device)
        model.load_state_dict(torch.load('weights/clean/cifar_nin.pth', map_location=device))

        evaluate_attack('cifar_nin_fgsm.csv', 'results', device, model, cifar_loader_test, cifar_min, cifar_max, fgsm_eps, is_fgsm=T
        print('')

        deep_args = [64, 10, 0.02, 100]
        evaluate_attack('cifar_nin_deepfool.csv', 'results', device, model, cifar_loader_test, cifar_min, cifar_max, deep_args, is_f

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

        FGSM Test Error : 81.29%
        FGSM Robustness : 1.77e-01
        FGSM Time (All Images) : 0.67 s
        FGSM Time (Per Image) : 67.07 us

        DeepFool Test Error : 93.76%
        DeepFool Robustness : 2.12e-02
        DeepFool Time (All Images) : 185.12 s
        DeepFool Time (Per Image) : 18.51 ms
```

Рисунок 6. – Загрузка и оценка стойкости модели Network-In-Network Model к FGSM и DeepFool атакам на основе датасета CIFAR-10



```
In [7]: # Загрузка и оценка стойкости модели LeNet к FGSM и DeepFool атакам на основе датасета CIFAR-10
        fgsm_eps = 0.1

        model = LeNet_CIFAR().to(device)
        model.load_state_dict(torch.load('weights/clean/cifar_lenet.pth', map_location=device))

        evaluate_attack('cifar_lenet_fgsm.csv', 'results', device, model, cifar_loader_test, cifar_min, cifar_max, fgsm_eps, is_fgsm
        print('')

        deep_args = [64, 10, 0.02, 100]
        evaluate_attack('cifar_lenet_deepfool.csv', 'results', device, model, cifar_loader_test, cifar_min, cifar_max, deep_args, is

        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
```

Рисунок 7. – Загрузка и оценка стойкости модели LeNet к FGSM и DeepFool атакам на основе датасета CIFAR-10



```
In [8]: # LeNet MNIST
fgsm_eps = 0.6
model = LeNet_MNIST().to(device)
model.load_state_dict(torch.load('weights/clean/mnist_lenet.pth', map_location=torch.device('cpu')))
display_attack(device, model, mnist_test, mnist_tf_inv, mnist_min, mnist_max, fgsm_eps, deep_args,
               has_labels=False, l2_norm=True, pert_scale=1.0, fig_rows=2, fig_width=25, fig_height=11)

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

# FCNet MNIST
fgsm_eps = 0.2
model = FC_500_150().to(device)
model.load_state_dict(torch.load('weights/clean/mnist_fc.pth', map_location=torch.device('cpu')))
display_attack(device, model, mnist_test, mnist_tf_inv, mnist_min, mnist_max, fgsm_eps, deep_args,
               has_labels=False, l2_norm=True, pert_scale=1.0, fig_rows=2, fig_width=25, fig_height=11)

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

# Network-in-Network CIFAR-10
fgsm_eps = 0.2
model = Net().to(device)
model.load_state_dict(torch.load('weights/clean/cifar_nin.pth', map_location=torch.device('cpu')))
display_attack(device, model, cifar_test, cifar_tf_inv, cifar_min, cifar_max, fgsm_eps, deep_args,
               has_labels=False, l2_norm=True, pert_scale=1.0, fig_rows=2, fig_width=25, fig_height=11,
               label_map=cifar_classes)

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

# LeNet CIFAR-10
fgsm_eps = 0.1
model = LeNet_CIFAR().to(device)
model.load_state_dict(torch.load('weights/clean/cifar_lenet.pth', map_location=torch.device('cpu')))
display_attack(device, model, cifar_test, cifar_tf_inv, cifar_min, cifar_max, fgsm_eps, deep_args,
               has_labels=False, l2_norm=True, pert_scale=1.0, fig_rows=2, fig_width=25, fig_height=11,
               label_map=cifar_classes)


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

Рисунок 8. – Оценка атакующих примеров

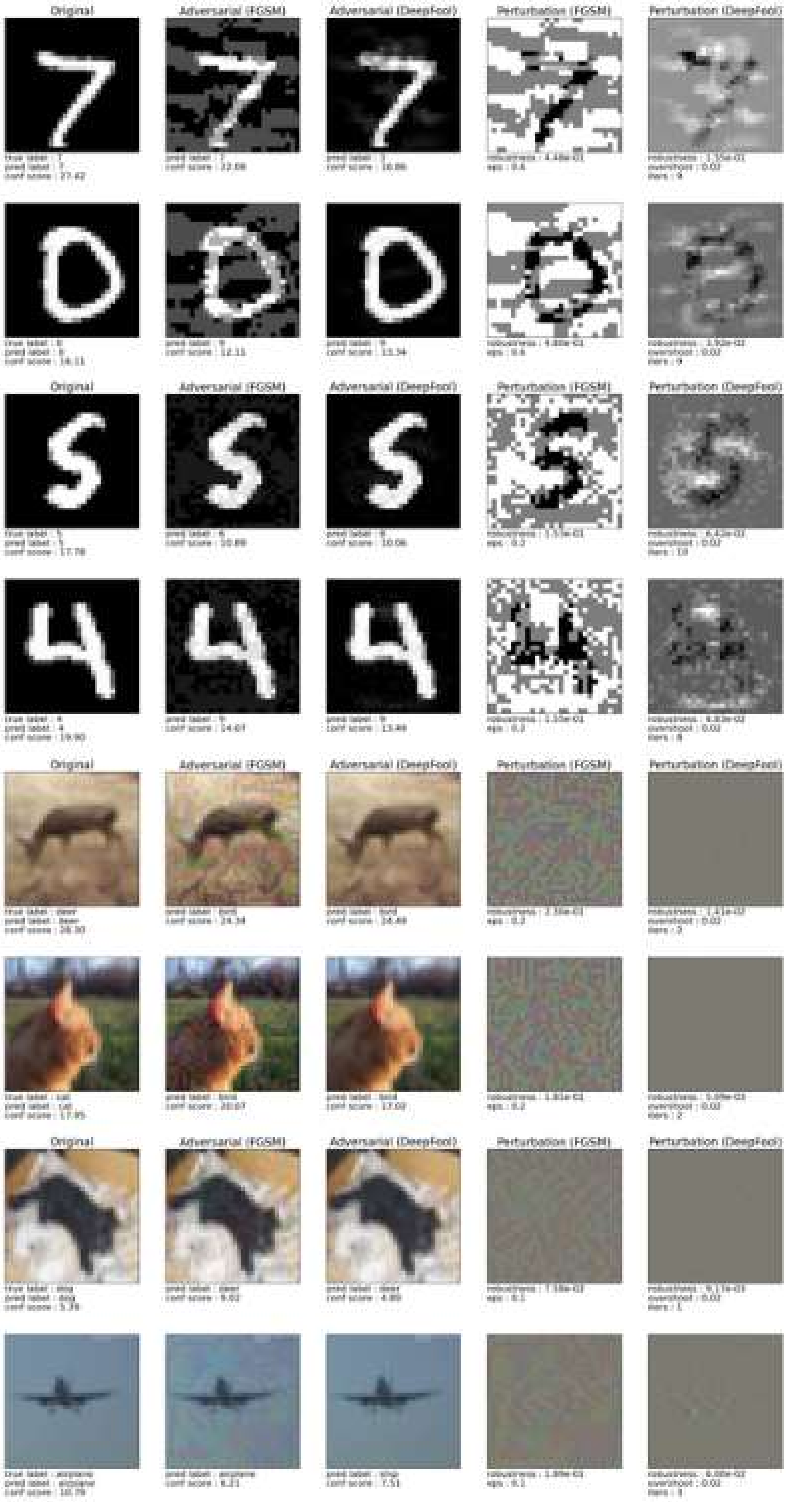
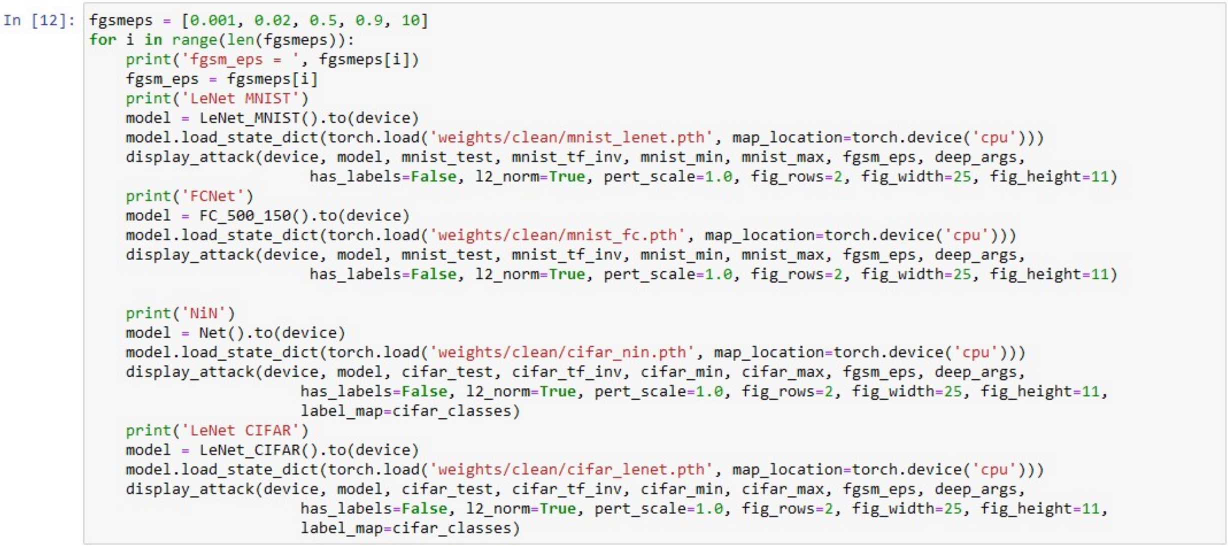


Рисунок 9. – Оценка атакующих примеров



```
In [12]: fgsmeps = [0.001, 0.02, 0.5, 0.9, 10]
         for i in range(len(fgsmeps)):
             print('fgsm_eps = ', fgsmeps[i])
             fgsm_eps = fgsmeps[i]
             print('LeNet MNIST')
             model = LeNet_MNIST().to(device)
             model.load_state_dict(torch.load('weights/clean/mnist_lenet.pth', map_location=torch.device('cpu')))
             display_attack(device, model, mnist_test, mnist_tf_inv, mnist_min, mnist_max, fgsm_eps, deep_args,
                                 has_labels=False, l2_norm=True, pert_scale=1.0, fig_rows=2, fig_width=25, fig_height=11)
             print('FCNet')
             model = FC_500_150().to(device)
             model.load_state_dict(torch.load('weights/clean/mnist_fc.pth', map_location=torch.device('cpu')))
             display_attack(device, model, mnist_test, mnist_tf_inv, mnist_min, mnist_max, fgsm_eps, deep_args,
                                 has_labels=False, l2_norm=True, pert_scale=1.0, fig_rows=2, fig_width=25, fig_height=11)

             print('NiN')
             model = Net().to(device)
             model.load_state_dict(torch.load('weights/clean/cifar_nin.pth', map_location=torch.device('cpu')))
             display_attack(device, model, cifar_test, cifar_tf_inv, cifar_min, cifar_max, fgsm_eps, deep_args,
                                has_labels=False, l2_norm=True, pert_scale=1.0, fig_rows=2, fig_width=25, fig_height=11,
                                label_map=cifar_classes)
             print('LeNet CIFAR')
             model = LeNet_CIFAR().to(device)
             model.load_state_dict(torch.load('weights/clean/cifar_lenet.pth', map_location=torch.device('cpu')))
             display_attack(device, model, cifar_test, cifar_tf_inv, cifar_min, cifar_max, fgsm_eps, deep_args,
                                has_labels=False, l2_norm=True, pert_scale=1.0, fig_rows=2, fig_width=25, fig_height=11,
                                label_map=cifar_classes)
```

Рисунок 10. – Перебор различных значений fgsp_eps

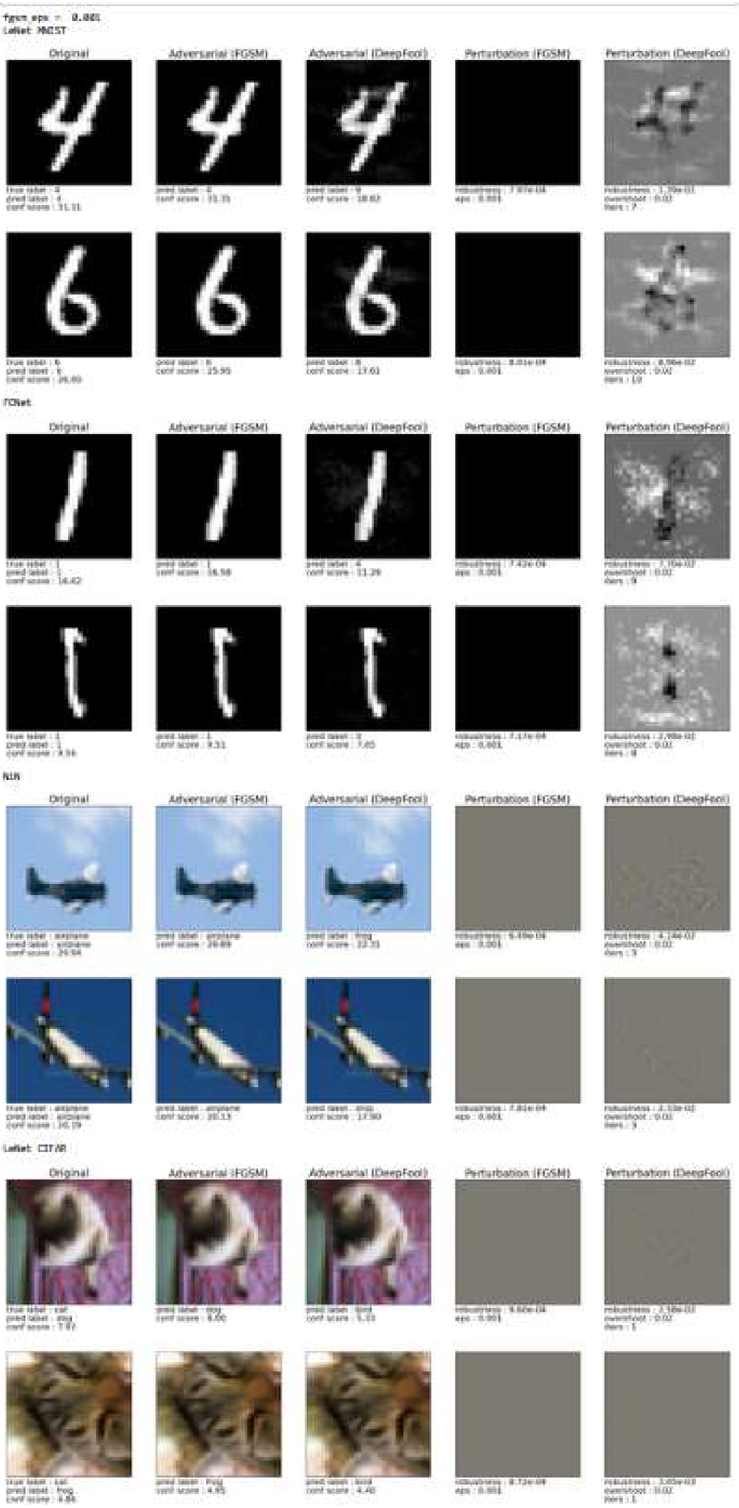
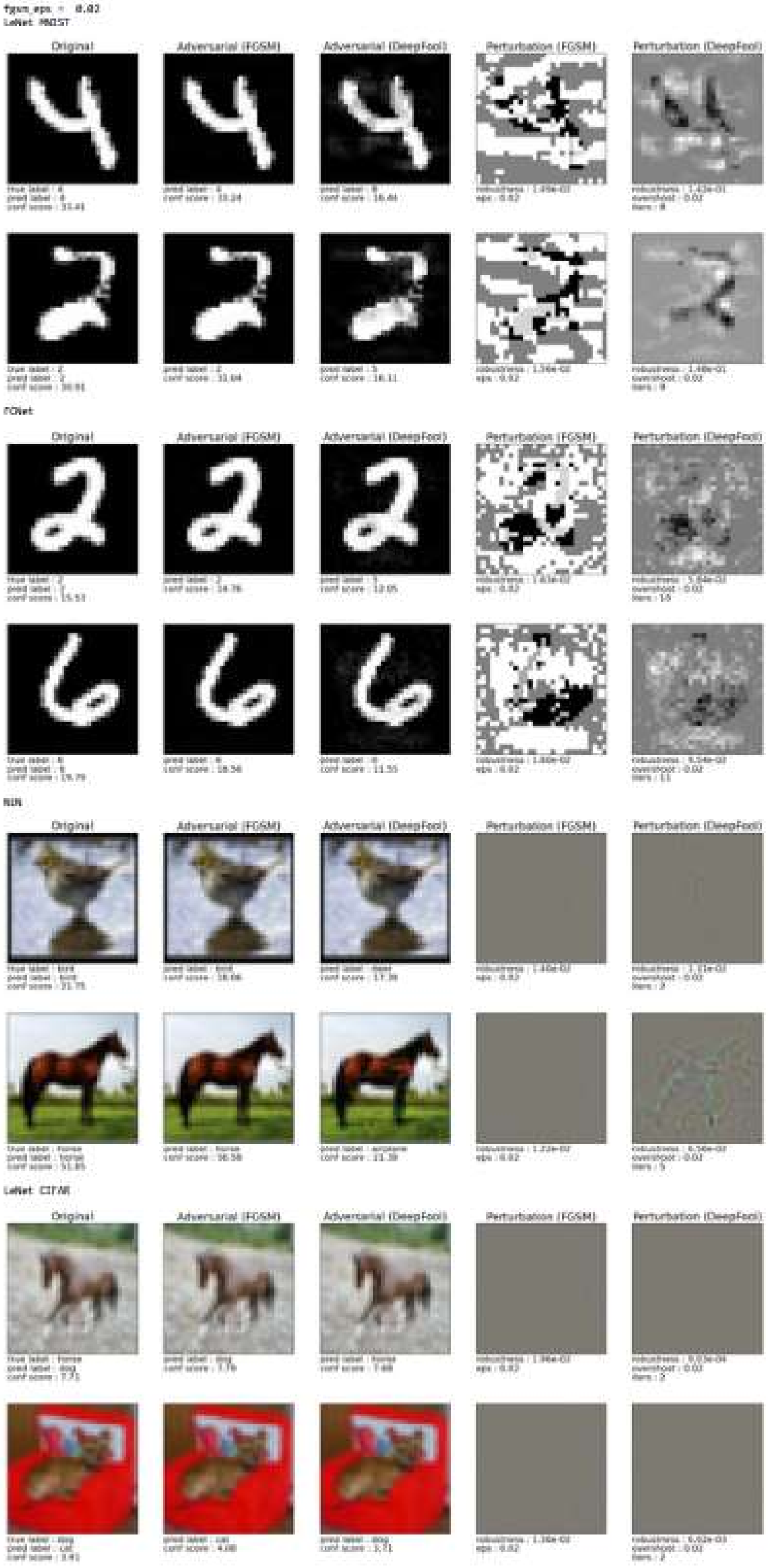
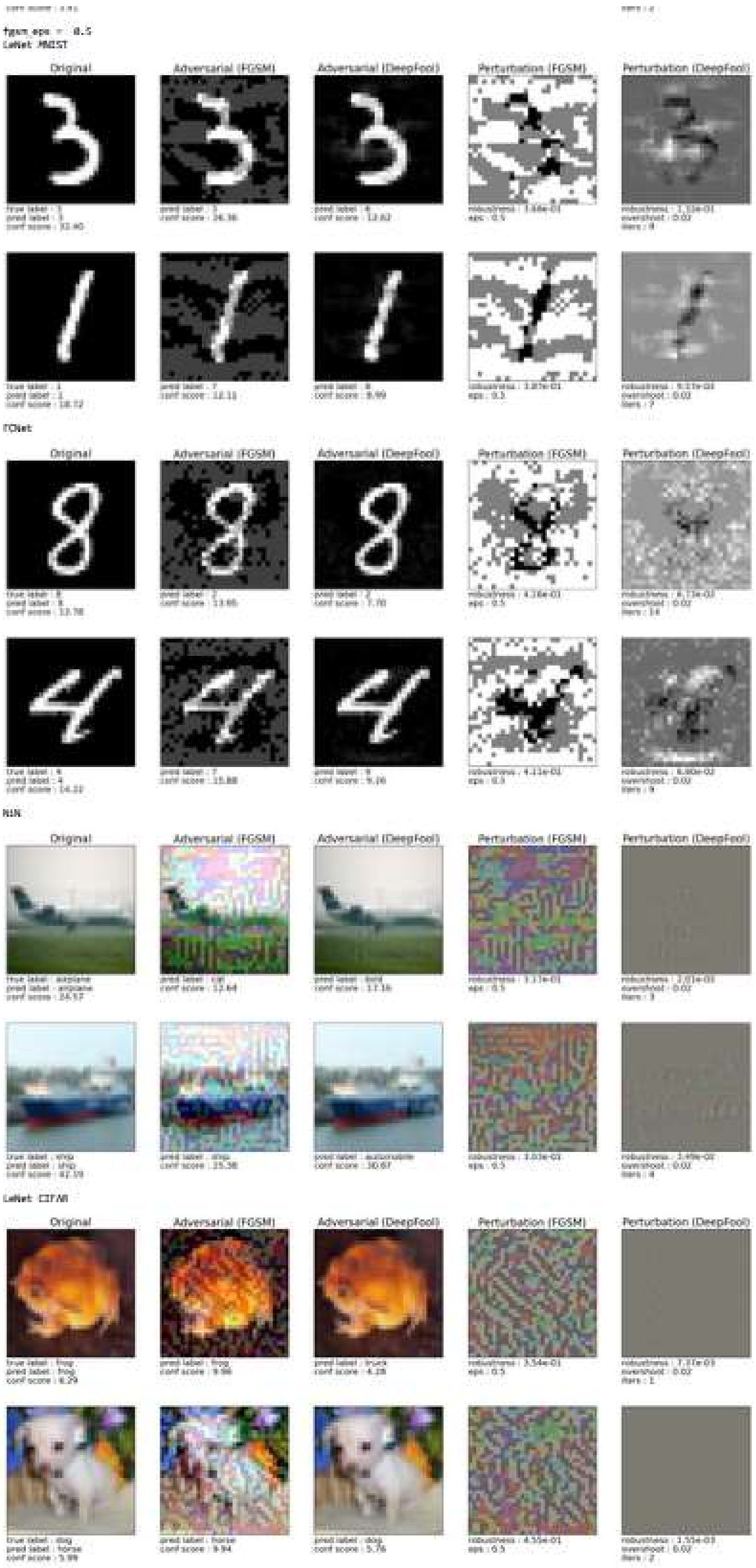


Рисунок 11. – fgsp_eps = 0.001



```
fgsm_eps =  0.02
LeNet MNIST

true label : 4      pred label : 4      pred label : 9      robustness : 1.49e-02   robustness : 1.43e-01
pred label : 4      conf score : 33.24  conf score : 16.46  eps : 0.02              overshoot : 0.02
conf score : 33.41                                                                  iters : 8

true label : 2      pred label : 2      pred label : 5      robustness : 1.56e-02   robustness : 1.48e-01
pred label : 2      conf score : 33.64  conf score : 16.11  eps : 0.02              overshoot : 0.02
conf score : 30.91                                                                  iters : 8

FCNet

true label : 2      pred label : 2      pred label : 3      robustness : 1.61e-02   robustness : 5.54e-02
pred label : 2      conf score : 14.76  conf score : 12.05  eps : 0.02              overshoot : 0.02
conf score : 15.53                                                                  iters : 15

true label : 6      pred label : 6      pred label : 0      robustness : 1.80e-02   robustness : 9.54e-02
pred label : 6      conf score : 18.56  conf score : 11.55  eps : 0.02              overshoot : 0.02
conf score : 19.79                                                                  iters : 11

NIN

true label : bird   pred label : bird   pred label : deer   robustness : 1.40e-02   robustness : 1.11e-02
pred label : bird   conf score : 18.06  conf score : 17.39  eps : 0.02              overshoot : 0.02
conf score : 21.75                                                                  iters : 2

true label : horse  pred label : horse  pred label : airplane  robustness : 1.22e-02   robustness : 6.56e-03
pred label : horse  conf score : 50.58  conf score : 21.39     eps : 0.02              overshoot : 0.02
conf score : 51.85                                                                     iters : 5

LeNet CIFAR

true label : horse  pred label : dog    pred label : horse  robustness : 1.96e-02   robustness : 6.03e-04
pred label : dog    conf score : 7.76   conf score : 7.68   eps : 0.02              overshoot : 0.02
conf score : 7.71                                                                   iters : 2

true label : dog    pred label : cat    pred label : dog    robustness : 1.30e-02   robustness : 6.02e-03
pred label : cat    conf score : 4.08   conf score : 3.71   eps : 0.02              overshoot : 0.02
conf score : 3.41                                                                   iters : 2
```

Рисунок 12. – fgsp_eps = 0.02



conf score : 3.91
iters : 2

fgsm_eps = 0.5
LeNet MNIST

Original
Adversarial (FGSM)
Adversarial (DeepFool)
Perturbation (FGSM)
Perturbation (DeepFool)

true label : 3
pred label : 3
conf score : 33.40
pred label : 3
conf score : 26.36
pred label : 4
conf score : 12.62
robustness : 3.68e-01
eps : 0.5
robustness : 1.32e-01
overshoot : 0.02
iters : 8

true label : 1
pred label : 1
conf score : 18.72
pred label : 7
conf score : 12.11
pred label : 8
conf score : 8.99
robustness : 3.87e-01
eps : 0.5
robustness : 5.17e-03
overshoot : 0.02
iters : 7

FCNet

Original
Adversarial (FGSM)
Adversarial (DeepFool)
Perturbation (FGSM)
Perturbation (DeepFool)

true label : 8
pred label : 8
conf score : 13.78
pred label : 2
conf score : 13.65
pred label : 2
conf score : 7.70
robustness : 4.16e-01
eps : 0.5
robustness : 6.11e-02
overshoot : 0.02
iters : 14

true label : 4
pred label : 4
conf score : 14.22
pred label : 7
conf score : 15.88
pred label : 9
conf score : 9.26
robustness : 4.11e-01
eps : 0.5
robustness : 6.80e-02
overshoot : 0.02
iters : 9

NiN

Original
Adversarial (FGSM)
Adversarial (DeepFool)
Perturbation (FGSM)
Perturbation (DeepFool)

true label : airplane
pred label : airplane
conf score : 24.57
pred label : cat
conf score : 12.64
pred label : bird
conf score : 17.16
robustness : 3.17e-01
eps : 0.5
robustness : 2.01e-03
overshoot : 0.02
iters : 3

true label : ship
pred label : ship
conf score : 42.19
pred label : ship
conf score : 25.38
pred label : automobile
conf score : 30.67
robustness : 3.03e-01
eps : 0.5
robustness : 3.49e-03
overshoot : 0.02
iters : 4

LeNet CIFAR

Original
Adversarial (FGSM)
Adversarial (DeepFool)
Perturbation (FGSM)
Perturbation (DeepFool)

true label : frog
pred label : frog
conf score : 6.29
pred label : frog
conf score : 9.96
pred label : truck
conf score : 4.28
robustness : 3.54e-01
eps : 0.5
robustness : 7.37e-03
overshoot : 0.02
iters : 1

true label : dog
pred label : horse
conf score : 5.99
pred label : horse
conf score : 9.94
pred label : dog
conf score : 5.76
robustness : 4.55e-01
eps : 0.5
robustness : 1.55e-03
overshoot : 0.02
iters : 2

Рисунок 13. – fgsp_eps = 0.5

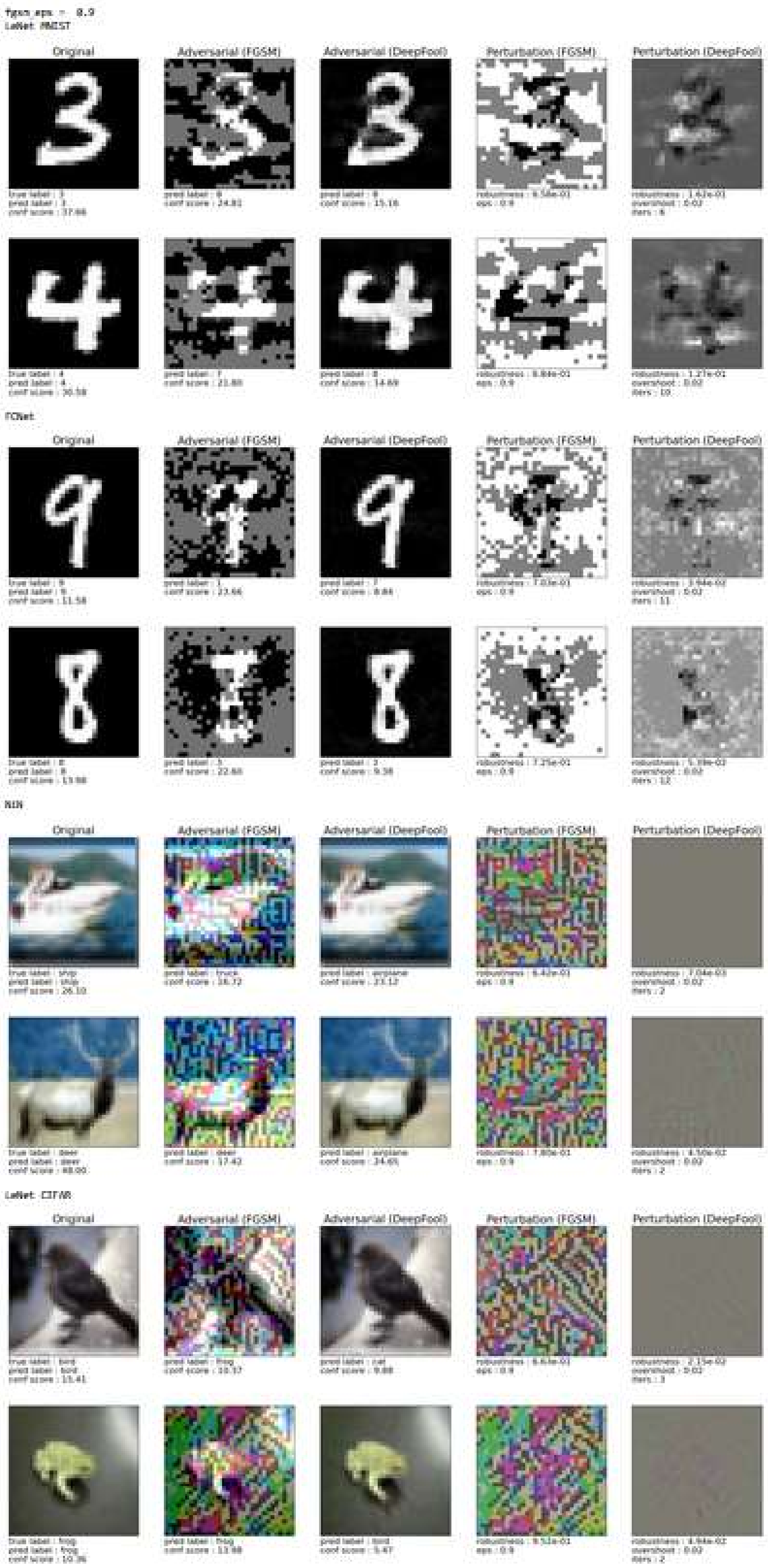


Рисунок 14. – fgsp_eps = 0.9

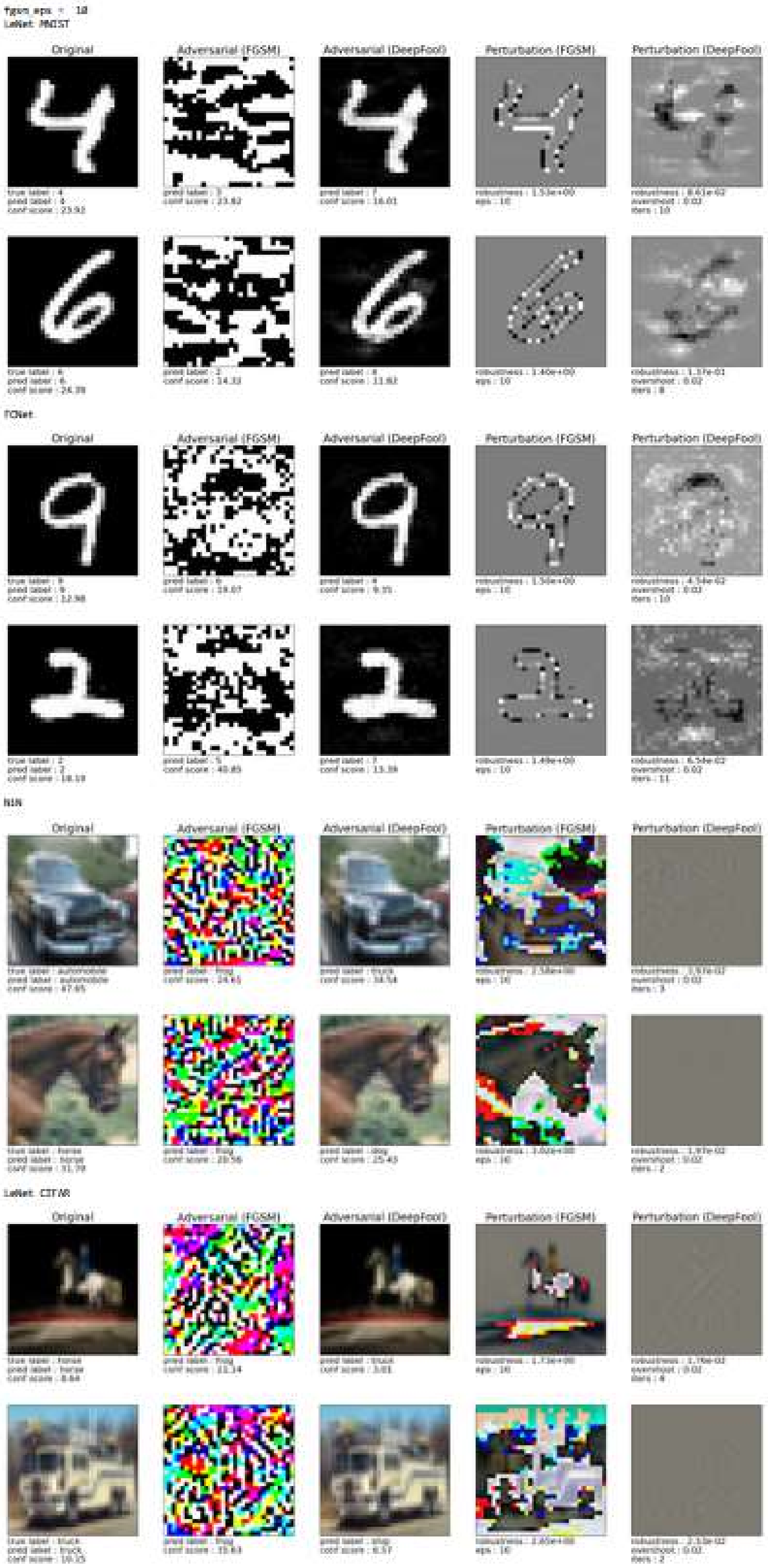


Рисунок 12. – fgsp_eps = 10

Вывод:

При низких значениях fgsm_eps FGSM не смог вызвать ошибку в распознавании, в то же время при больших значениях fgsm_eps вмешательство становиться слишком заметных.

DeepFool смог ввести сеть в заблуждение при всех значениях параметра fgsm_eps, при этом вмешательство в исходное изображение почти не заметно.