Fast_Gradient_Sign_Method_Adversarial_Attack

April 18, 2022

1 Fast Gradient Sign Method Adversarial Attack

Code based on University of Amsterdam Deep Learning Course.

1.1 Import Libraries

[1]:

```
## Standard libraries
import os
import json
import math
import time
import numpy as np
import scipy.linalg

## Imports for plotting
import matplotlib.pyplot as plt
%matplotlib inline
from IPython.display import set_matplotlib_formats
set_matplotlib_formats('svg', 'pdf') # For export
from matplotlib.colors import to_rgb
import matplotlib
matplotlib.rcParams['lines.linewidth'] = 2.0
import seaborn as sns
sns.set()

## Progress bar
from tqdm.notebook import tqdm

## PyTorch
import torch
import torch.nn as nn
import torch.nn.functional as F
import torch.utils.data as data
import torch.optim as optim
# Torchvision
import torchvision
from torchvision.datasets import CIFAR10
from torchvision import transforms
```

```
# PyTorch Lightning
try:
    import pytorch_lightning as pl
except ModuleNotFoundError: # Google Colab does not have PyTorch Lightning␣
 ↪installed by default. Hence, we do it here if necessary
    !pip install --quiet pytorch-lightning>=1.4
    import pytorch_lightning as pl
from pytorch_lightning.callbacks import LearningRateMonitor, ModelCheckpoint

# Path to the folder where the datasets are/should be downloaded (e.g. MNIST)
DATASET_PATH = "../data"
# Path to the folder where the pretrained models are saved
CHECKPOINT_PATH = "../saved_models/tutorial10"

# Setting the seed
pl.seed_everything(42)

# Ensure that all operations are deterministic on GPU (if used) for␣
 ↪reproducibility
torch.backends.cudnn.determinstic = True
torch.backends.cudnn.benchmark = False

# Fetching the device that will be used throughout this notebook
device = torch.device("cpu") if not torch.cuda.is_available() else torch.
 ↪device("cuda:0")
print("Using device", device)
```

```
Global seed set to 42
```

```
Using device cpu
```

1.2 Download Dataset and Patches

[2]:

```
import urllib.request
from urllib.error import HTTPError
import zipfile
# Github URL where the dataset is stored for this tutorial
base_url = "https://raw.githubusercontent.com/phlippe/saved_models/main/
 ↪tutorial10/"
# Files to download
pretrained_files = [(DATASET_PATH, "TinyImageNet.zip"), (CHECKPOINT_PATH,␣
 ↪"patches.zip")]
# Create checkpoint path if it doesn't exist yet
os.makedirs(DATASET_PATH, exist_ok=True)
os.makedirs(CHECKPOINT_PATH, exist_ok=True)

# For each file, check whether it already exists. If not, try downloading it.
```

```
for dir_name, file_name in pretrained_files:
    file_path = os.path.join(dir_name, file_name)
    if not os.path.isfile(file_path):
        file_url = base_url + file_name
        print(f"Downloading {file_url}...")
        try:
            urllib.request.urlretrieve(file_url, file_path)
        except HTTPError as e:
            print("Something went wrong. Please try to download the file from␣
 ↪the GDrive folder, or contact the author with the full output including the␣
 ↪following error:\n", e)
        if file_name.endswith(".zip"):
            print("Unzipping file...")
            with zipfile.ZipFile(file_path, 'r') as zip_ref:
                zip_ref.extractall(file_path.rsplit("/",1)[0])
```

```
Downloading https://raw.githubusercontent.com/phlippe/saved_models/main/tutorial
10/TinyImageNet.zip…
Unzipping file…
Downloading https://raw.githubusercontent.com/phlippe/saved_models/main/tutorial
10/patches.zip…
Unzipping file…
```

1.3 Load CNN, Dataset and Dataloader

[3]:

```
# Load CNN architecture pretrained on ImageNet
os.environ["TORCH_HOME"] = CHECKPOINT_PATH
pretrained_model = torchvision.models.resnet34(pretrained=True)
pretrained_model = pretrained_model.to(device)

# No gradients needed for the network
pretrained_model.eval()
for p in pretrained_model.parameters():
    p.requires_grad = False
```

```
Downloading: "https://download.pytorch.org/models/resnet34-b627a593.pth" to
../saved_models/tutorial10/hub/checkpoints/resnet34-b627a593.pth

  0%|          | 0.00/83.3M [00:00<?, ?B/s]
```

[4]:

```
# Mean and Std from ImageNet
NORM_MEAN = np.array([0.485, 0.456, 0.406])
NORM_STD = np.array([0.229, 0.224, 0.225])
# No resizing and center crop necessary as images are already preprocessed.
plain_transforms = transforms.Compose([
    transforms.ToTensor(),
    transforms.Normalize(mean=NORM_MEAN,
                         std=NORM_STD)
])

# Load dataset and create data loader
imagenet_path = os.path.join(DATASET_PATH, "TinyImageNet/")
assert os.path.isdir(imagenet_path), f"Could not find the ImageNet dataset at␣
 ↪expected path \"{imagenet_path}\". " + \
                                      f"Please make sure to have downloaded the␣
 ↪ImageNet dataset here, or change the {DATASET_PATH} variable."
dataset = torchvision.datasets.ImageFolder(root=imagenet_path,␣
 ↪transform=plain_transforms)
data_loader = data.DataLoader(dataset, batch_size=32, shuffle=False,␣
 ↪drop_last=False, num_workers=2)

# Load label names to interpret the label numbers 0 to 999
with open(os.path.join(imagenet_path, "label_list.json"), "r") as f:
    label_names = json.load(f)

def get_label_index(lab_str):
    assert lab_str in label_names, f"Label \"{lab_str}\" not found. Check the␣
 ↪spelling of the class."
    return label_names.index(lab_str)
```

1.4 Define Auxiliar Functions

- Show Prediction
- Fast Gradient Sign Method

[5]:

```
def show_prediction(img, label, pred, K=5, adv_img=None, noise=None):

    if isinstance(img, torch.Tensor):
        # Tensor image to numpy
        img = img.cpu().permute(1, 2, 0).numpy()
        img = (img * NORM_STD[None,None]) + NORM_MEAN[None,None]
        img = np.clip(img, a_min=0.0, a_max=1.0)
        label = label.item()

    # Plot on the left the image with the true label as title.
    # On the right, have a horizontal bar plot with the top k predictions␣
 ↪including probabilities
    if noise is None or adv_img is None:
        fig, ax = plt.subplots(1, 2, figsize=(10,2),␣
 ↪gridspec_kw={'width_ratios': [1, 1]})
    else:
        fig, ax = plt.subplots(1, 5, figsize=(12,2),␣
 ↪gridspec_kw={'width_ratios': [1, 1, 1, 1, 2]})

    ax[0].imshow(img)
    ax[0].set_title(label_names[label])
    ax[0].axis('off')

    if adv_img is not None and noise is not None:
        # Visualize adversarial images
        adv_img = adv_img.cpu().permute(1, 2, 0).numpy()
        adv_img = (adv_img * NORM_STD[None,None]) + NORM_MEAN[None,None]
        adv_img = np.clip(adv_img, a_min=0.0, a_max=1.0)
        ax[1].imshow(adv_img)
        ax[1].set_title('Adversarial')
        ax[1].axis('off')
        # Visualize noise
        noise = noise.cpu().permute(1, 2, 0).numpy()
        noise = noise * 0.5 + 0.5 # Scale between 0 to 1
        ax[2].imshow(noise)
        ax[2].set_title('Noise')
        ax[2].axis('off')
        # buffer
        ax[3].axis('off')

    if abs(pred.sum().item() - 1.0) > 1e-4:
        pred = torch.softmax(pred, dim=-1)
    topk_vals, topk_idx = pred.topk(K, dim=-1)
    topk_vals, topk_idx = topk_vals.cpu().numpy(), topk_idx.cpu().numpy()
    ax[-1].barh(np.arange(K), topk_vals*100.0, align='center', color=["C0" if topk_idx[i]!=label else "C2" for i in range(K)])
    ax[-1].set_yticks(np.arange(K))
    ax[-1].set_yticklabels([label_names[c] for c in topk_idx])
    ax[-1].invert_yaxis()
    ax[-1].set_xlabel('Confidence')
    ax[-1].set_title('Predictions')

    plt.show()
    plt.close()
```

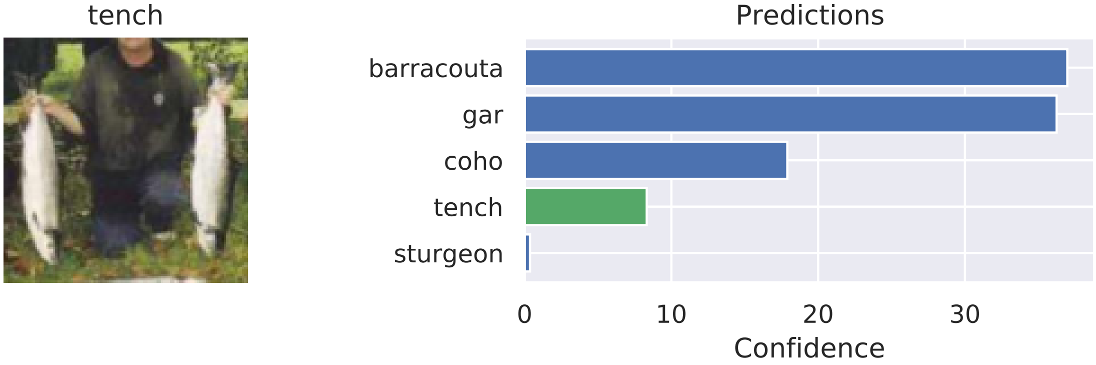
[6]:

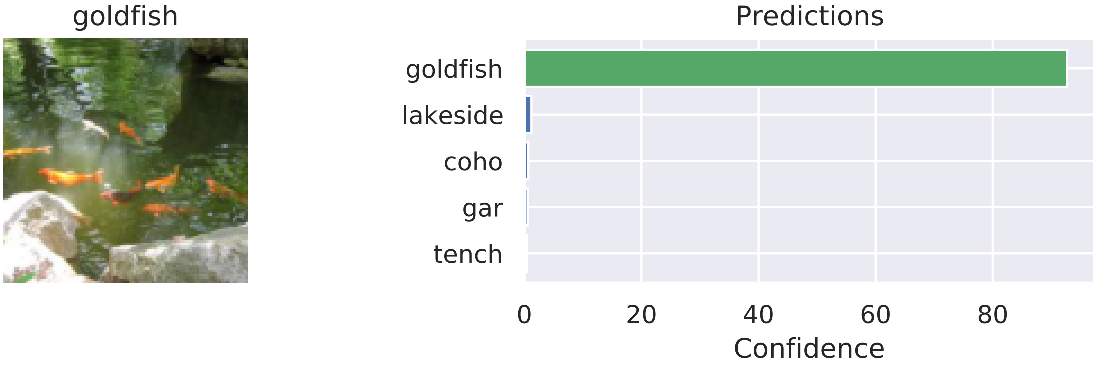
```
def fast_gradient_sign_method(model, imgs, labels, epsilon=0.02):
    # Determine prediction of the model
    inp_imgs = imgs.clone().requires_grad_()
    preds = model(inp_imgs.to(device))
    preds = F.log_softmax(preds, dim=-1)
    # Calculate loss by NLL
    loss = -torch.gather(preds, 1, labels.to(device).unsqueeze(dim=-1))
    loss.sum().backward()
    # Update image to adversarial example as written above
    noise_grad = torch.sign(inp_imgs.grad.to(imgs.device))
    fake_imgs = imgs + epsilon * noise_grad
    fake_imgs.detach_()
    return fake_imgs, noise_grad
```

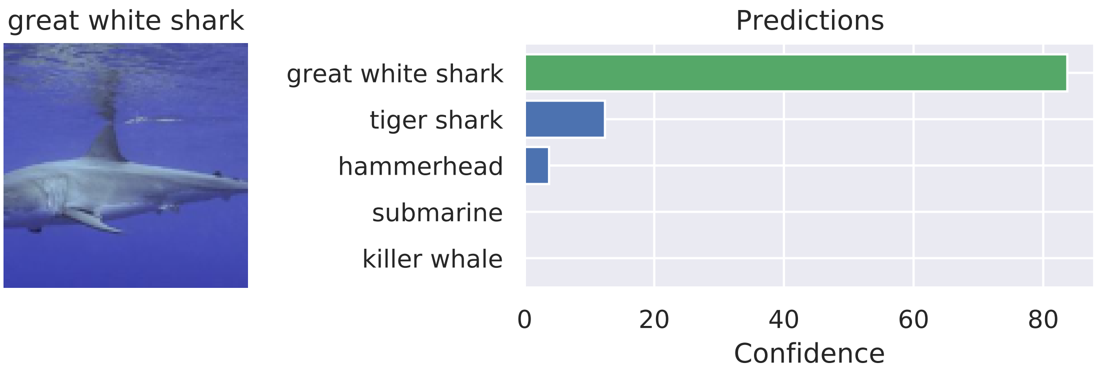
1.5 Show Correct Predictions

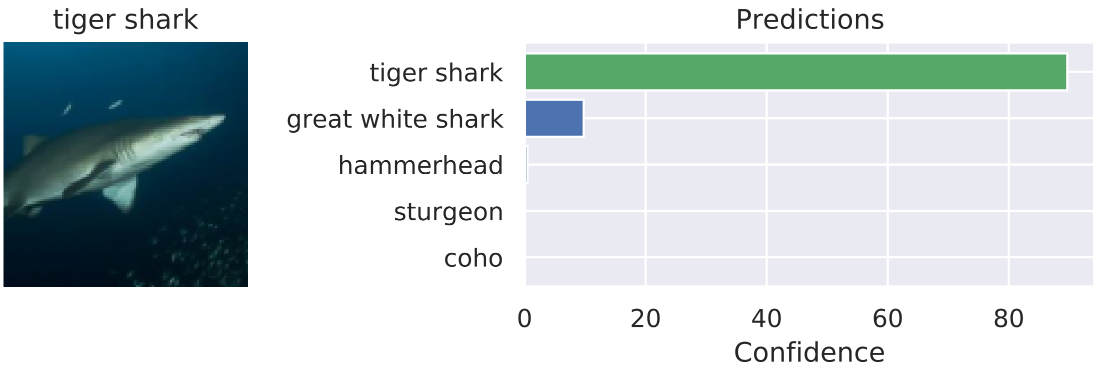
[8]:

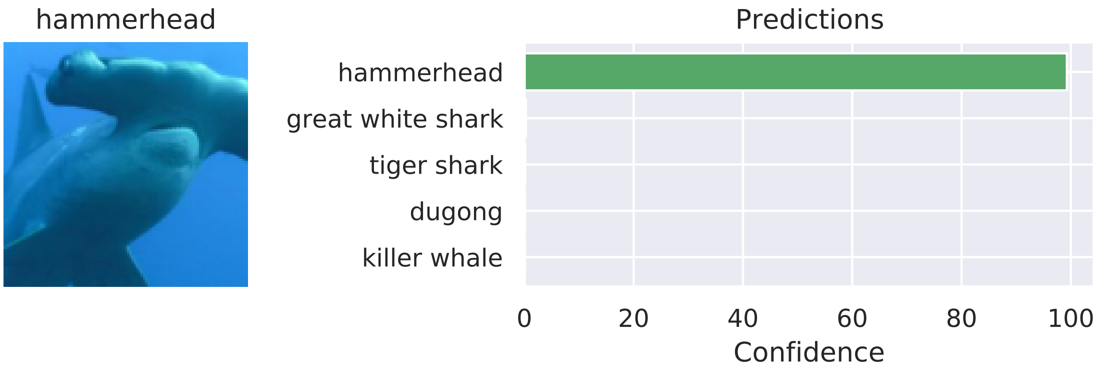
```
exmp_batch, label_batch = next(iter(data_loader))
with torch.no_grad():
    preds = pretrained_model(exmp_batch.to(device))
for i in range(2,29,5):
    show_prediction(exmp_batch[i], label_batch[i], preds[i])
```

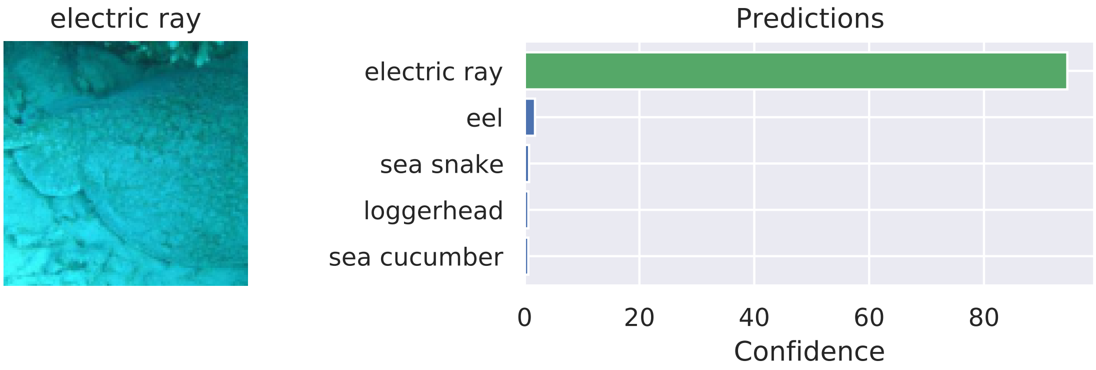





great white shark
Predictions
great white shark
tiger shark
hammerhead
submarine
killer whale
0
20
40
60
80
Confidence

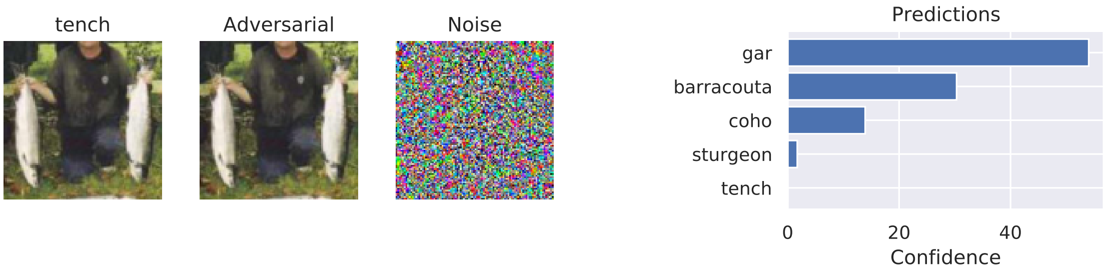

tiger shark
Predictions
tiger shark
great white shark
hammerhead
sturgeon
coho
0
20
40
60
80
Confidence

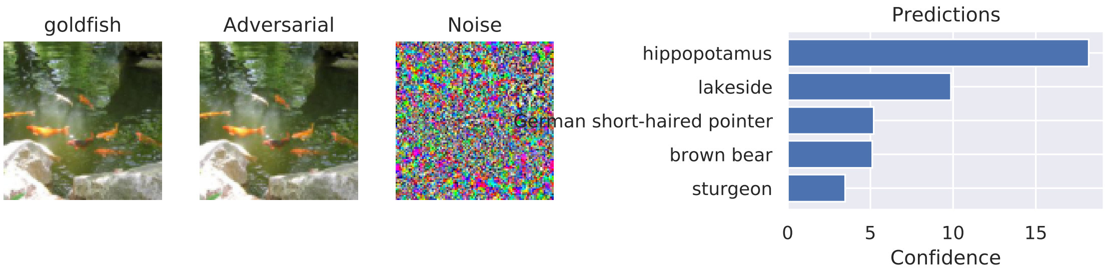

hammerhead
Predictions
hammerhead
great white shark
tiger shark
dugong
killer whale
0
20
40
60
80
100
Confidence

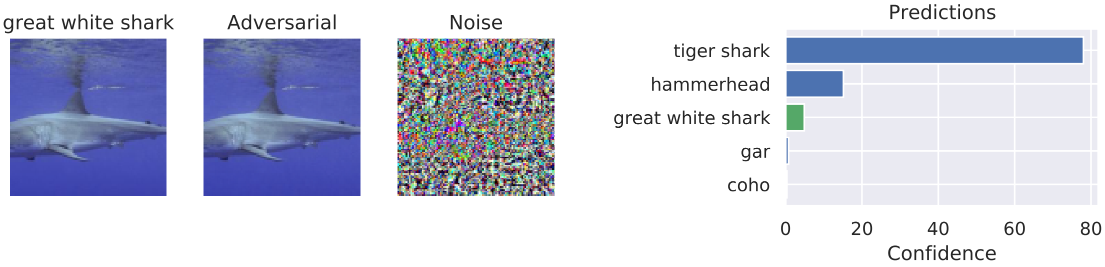


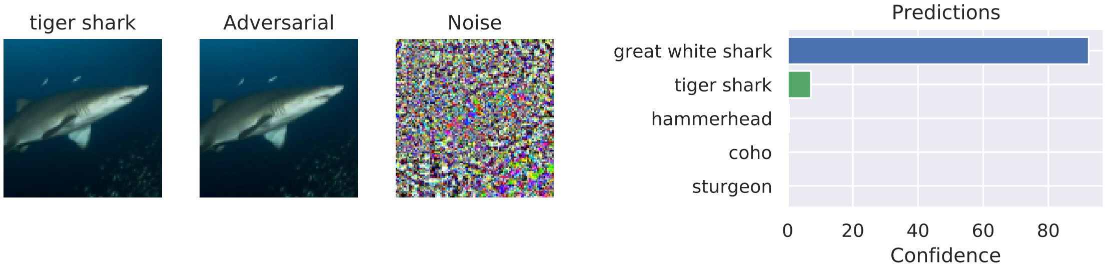
1.6 Add Patches and Show Predictions

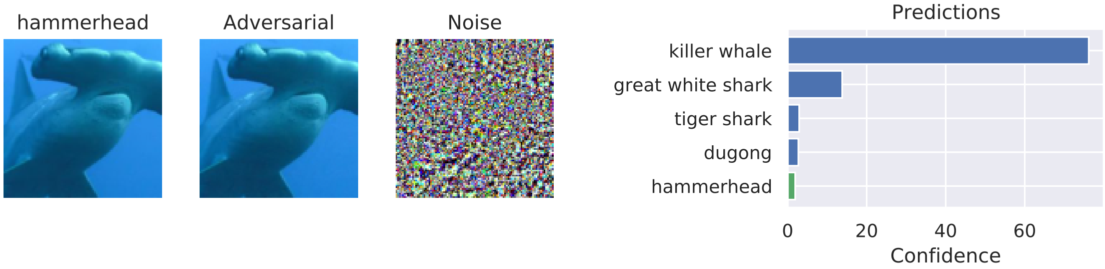
[9]:
```
adv_imgs, noise_grad = fast_gradient_sign_method(pretrained_model, exmp_batch,␣
 ↪label_batch, epsilon=0.02)
with torch.no_grad():
    adv_preds = pretrained_model(adv_imgs.to(device))

for i in range(2,29,5):
    show_prediction(exmp_batch[i], label_batch[i], adv_preds[i],␣
 ↪adv_img=adv_imgs[i], noise=noise_grad[i])
```

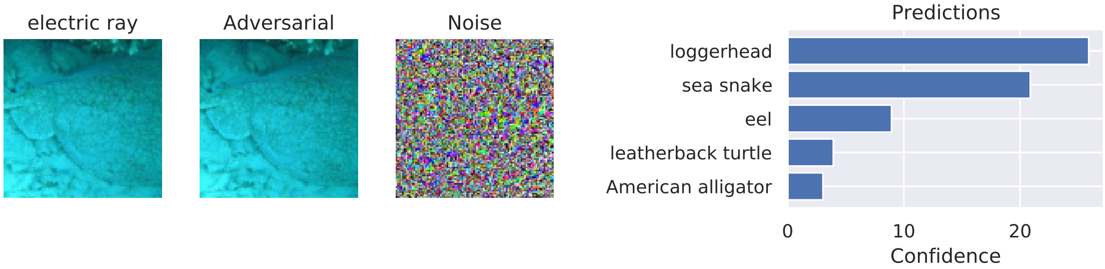





great white shark
Adversarial
Noise
Predictions
tiger shark
hammerhead
great white shark
gar
coho
0
20
40
60
80
Confidence


tiger shark
Adversarial
Noise
Predictions
great white shark
tiger shark
hammerhead
coho
sturgeon
0
20
40
60
80
Confidence


hammerhead
Adversarial
Noise
Predictions
killer whale
great white shark
tiger shark
dugong
hammerhead
0
20
40
60
Confidence


electric ray
Adversarial
Noise
Predictions
loggerhead
sea snake
eel
leatherback turtle
American alligator
0
10
20
Confidence