adversarial_patches_Jin

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1 Adversarial Patches

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This notebook shows the creation of an adversarial patch and tests it by adding it to image classfication examples. A creative component is added by combining different patches to test the impact on model performance.

Note My Colab has a built in assistant from Gemini that provided suggestions on the code. The adversarial_attacks_patches.ipynb notebook from the course Github page was also referenced to where most of the code comes from. The markdown explanations were written in my own words with no AI assistance.

1.0.1 Setup

The following sections were transferred over from the notebook from the course GitHub.

[1]:
```
## Standard libraries
import os
import json
import math
import time
import numpy as np
import scipy.linalg
import random

## 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
```

```
/tmp/ipython-input-531261194.py:14: DeprecationWarning: `set_matplotlib_formats`
is deprecated since IPython 7.23, directly use
`matplotlib_inline.backend_inline.set_matplotlib_formats()`
  set_matplotlib_formats('svg', 'pdf') # For export
```

[2]:
```
# Path to the folder where the datasets are downloaded
DATASET_PATH = "./data"
# Path to the folder where the pretrained models are saved
CHECKPOINT_PATH = "./saved_models"

# Setting the seed
pl.seed_everything(42)

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

```
INFO:lightning_fabric.utilities.seed:Seed set to 42
```

```
Using device cuda:0
```

[ ]:
```
# Load CNN architecture pretrained on ImageNet
os.environ["TORCH_HOME"] = CHECKPOINT_PATH
pretrained_model = torchvision.models.resnet34(weights='IMAGENET1K_V1')
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
```

[4]:
```
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")]
# 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…
```

[ ]:
```
# 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=1000, shuffle=False,␣
 ↪drop_last=False, num_workers=8)

# 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)
```

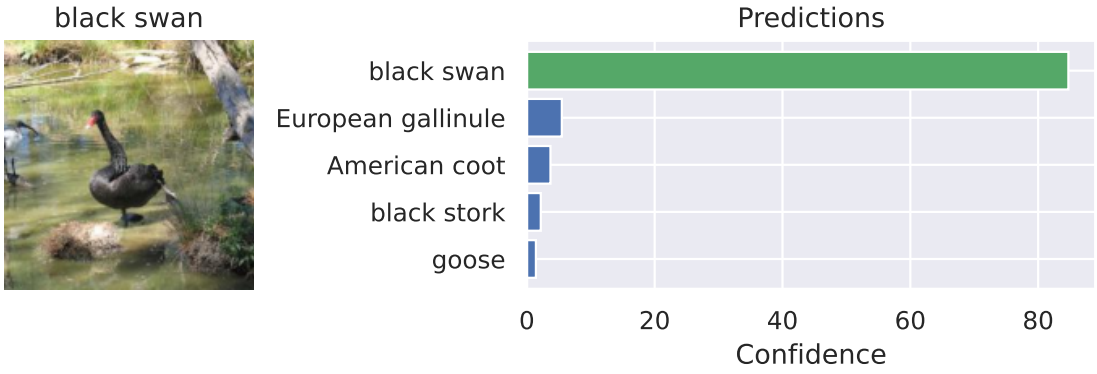
[6]:
```
def eval_model(dataset_loader, img_func=None):
    tp, tp_5, counter = 0., 0., 0.
    for imgs, labels in tqdm(dataset_loader, desc="Validating..."):
        imgs = imgs.to(device)
        labels = labels.to(device)
        if img_func is not None:
            imgs = img_func(imgs, labels)
        with torch.no_grad():
            preds = pretrained_model(imgs)
        tp += (preds.argmax(dim=-1) == labels).sum()
        tp_5 += (preds.topk(5, dim=-1)[1] == labels[...,None]).any(dim=-1).sum()
        counter += preds.shape[0]
    acc = tp.float().item()/counter
    top5 = tp_5.float().item()/counter
    print(f"Top-1 error: {(100.0 * (1 - acc)):4.2f}%")
    print(f"Top-5 error: {(100.0 * (1 - top5)):4.2f}%")
    return acc, top5
```

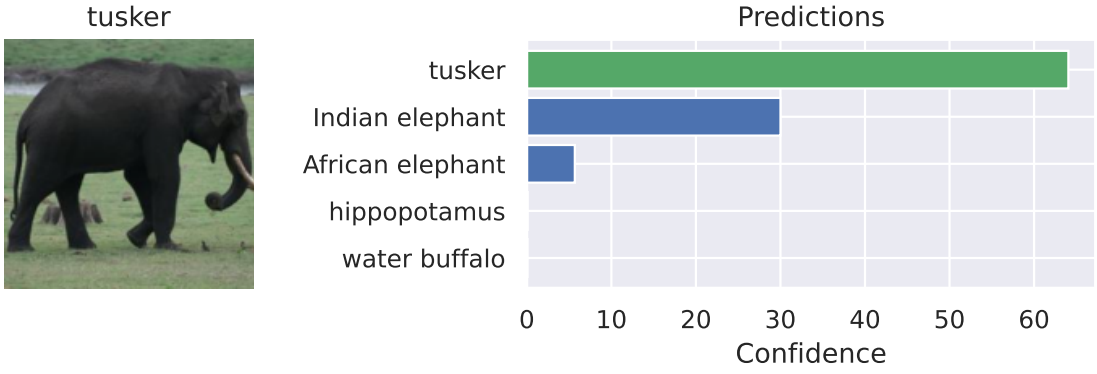
[ ]:
```
_ = eval_model(data_loader)
```

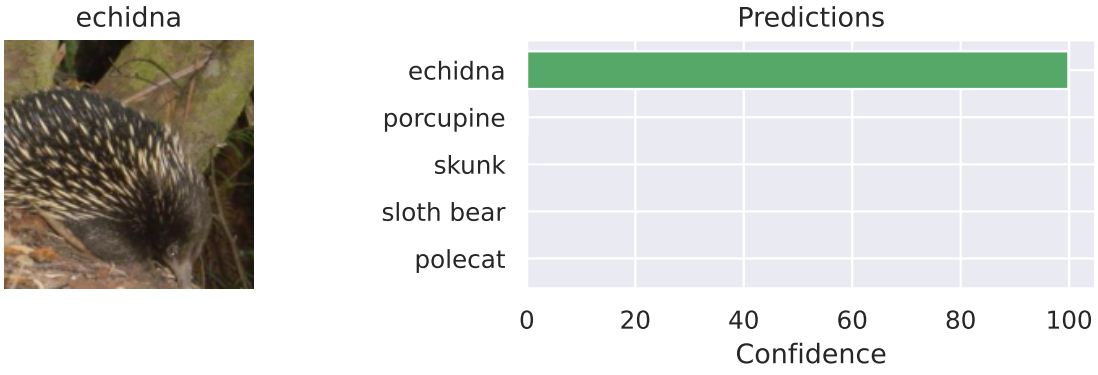
[8]:
```
def show_prediction(img, label, pred, K=5, adv_img=None, noise=None):

    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))
```

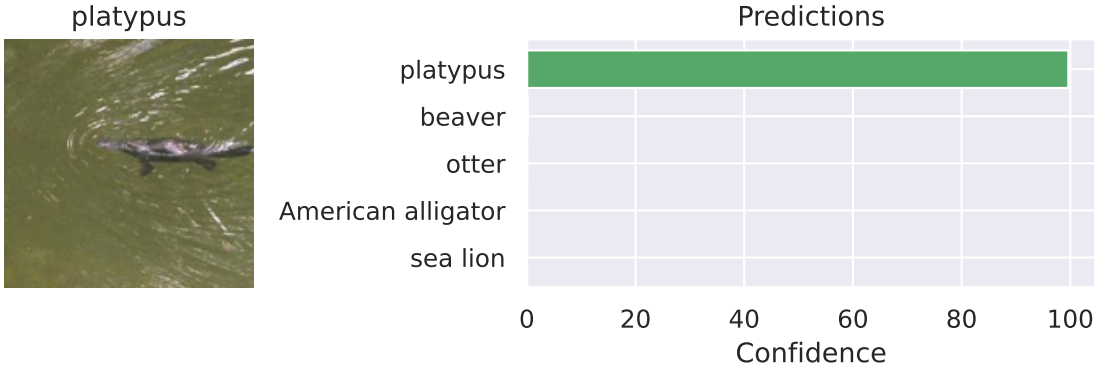
```
    ax[-1].set_yticklabels([label_names[c] for c in topk_idx])
    ax[-1].invert_yaxis()
    ax[-1].set_xlabel('Confidence')
    ax[-1].set_title('Predictions')

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

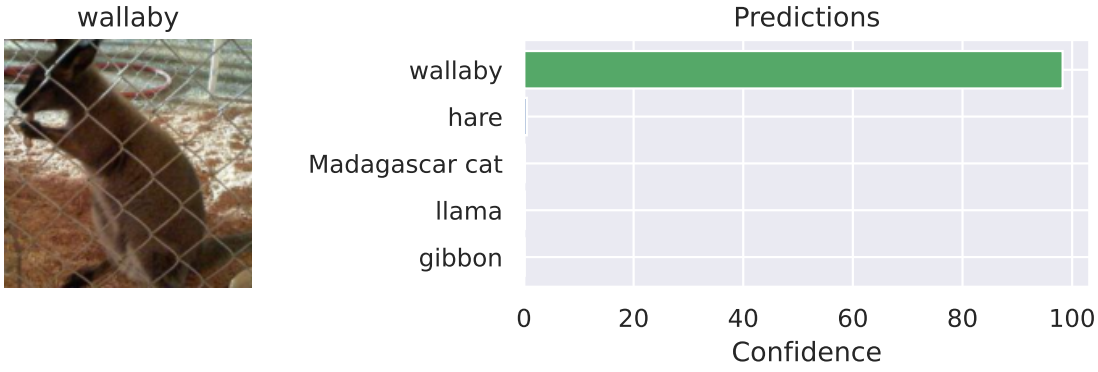
[9]:
```
# Preview several of the predictions
exmp_batch, label_batch = next(iter(data_loader))
with torch.no_grad():
    preds = pretrained_model(exmp_batch.to(device))
for i in range(500,525,5):
    show_prediction(exmp_batch[i], label_batch[i], preds[i])
```











1.0.2 Adversarial Patch Creation

This is where we create our patches and see how it affects our prediction. The functions were transferred from the course GitHub, but modified so that I could design my own patch.

[10]:
```
def place_patch(img, patch):
    for i in range(img.shape[0]):
        h_offset = np.random.randint(0,img.shape[2]-patch.shape[1]-1)
        w_offset = np.random.randint(0,img.shape[3]-patch.shape[2]-1)
        img[i,:,h_offset:h_offset+patch.shape[1],w_offset:w_offset+patch.
 ↪shape[2]] = patch_forward(patch)
    return img
```

[11]:
```
TENSOR_MEANS, TENSOR_STD = torch.FloatTensor(NORM_MEAN)[:,None,None], torch.
 ↪FloatTensor(NORM_STD)[:,None,None]
def patch_forward(patch):
    # Map patch values from [-infty,infty] to ImageNet min and max
    patch = (torch.tanh(patch) + 1 - 2 * TENSOR_MEANS) / (2 * TENSOR_STD)
    return patch
```

[12]:
```
def eval_patch(model, patch, val_loader, target_class):
    model.eval()
    tp, tp_5, counter = 0., 0., 0.
    with torch.no_grad():
        for img, img_labels in tqdm(val_loader, desc="Validating...",␣
 ↪leave=False):
            # For stability, place the patch at 4 random locations per image,␣
 ↪and average the performance
            for _ in range(4):
                patch_img = place_patch(img, patch)
                patch_img = patch_img.to(device)
                img_labels = img_labels.to(device)
                pred = model(patch_img)
                # In the accuracy calculation, we need to exclude the images␣
 ↪that are of our target class
                # as we would not "fool" the model into predicting those
                tp += torch.logical_and(pred.argmax(dim=-1) == target_class,␣
 ↪img_labels != target_class).sum()
                tp_5 += torch.logical_and((pred.topk(5, dim=-1)[1] ==␣
 ↪target_class).any(dim=-1), img_labels != target_class).sum()
                counter += (img_labels != target_class).sum()
    acc = tp/counter
    top5 = tp_5/counter
    return acc, top5
```

[13]:
```
def patch_attack(model, target_class, patch_size=64, num_epochs=5):
    # Leave a small set of images out to check generalization
    # In most of our experiments, the performance on the hold-out data points
    # was as good as on the training set. Overfitting was little possible due
    # to the small size of the patches.
    train_set, val_set = torch.utils.data.random_split(dataset, [4500, 500])
```

```
    train_loader = data.DataLoader(train_set, batch_size=32, shuffle=True,␣
↪drop_last=True, num_workers=8)
    val_loader = data.DataLoader(val_set, batch_size=32, shuffle=False,␣
↪drop_last=False, num_workers=4)

    # Create parameter and optimizer
    if not isinstance(patch_size, tuple):
        patch_size = (patch_size, patch_size)
    patch = nn.Parameter(torch.zeros(3, patch_size[0], patch_size[1]),␣
↪requires_grad=True)
    optimizer = torch.optim.SGD([patch], lr=1e-1, momentum=0.8)
    loss_module = nn.CrossEntropyLoss()

    # Training loop
    for epoch in range(num_epochs):
        t = tqdm(train_loader, leave=False)
        for img, _ in t:
            img = place_patch(img, patch)
            img = img.to(device)
            pred = model(img)
            labels = torch.zeros(img.shape[0], device=pred.device, dtype=torch.
↪long).fill_(target_class)
            loss = loss_module(pred, labels)
            optimizer.zero_grad()
            loss.mean().backward()
            optimizer.step()
            t.set_description(f"Epoch {epoch}, Loss: {loss.item():4.2f}")

    # Final validation
    acc, top5 = eval_patch(model, patch, val_loader, target_class)

    return patch.data, {"acc": acc.item(), "top5": top5.item()}
```

For the creative component, I attempt to make 3 different patches and combine them into one patch. It will be interesting to see how a patch containing different patches will affect the predictions. I will be creating and training patches to predict jackfruit, computer keyboard, and sports car, all of which are existing labels in the ImageNet dataset.

[ ]:
```
# Create custom patches
labels = ['jackfruit', 'computer keyboard', 'sports car']
patch_size = 64
patches = {}

# Loop to create each patch
for label in labels:
  print(f"Creating adversarial patch for: {label}")
  label_idx = label_names.index(label)
```

```
    patch, results = patch_attack(
        model=pretrained_model,
        target_class=label_idx,
        patch_size=patch_size,
        num_epochs=5
    )

    # Store and save patch
    patches[label] = {
        'patch': patch,
        'results': results
    }
    torch.save(patch, os.path.join(CHECKPOINT_PATH, f"{label}_{patch_size}_patch.pt"))
```

[15]:
```
# Load evaluation results of the pretrained patches
json_results_file = os.path.join(CHECKPOINT_PATH, "patch_results.json")
json_results = {}
if os.path.isfile(json_results_file):
    with open(json_results_file, "r") as f:
        json_results = json.load(f)

# If you train new patches, you can save the results via calling this function
def save_results(patch_dict):
    result_dict = {cname: {psize: [t.item() if isinstance(t, torch.Tensor) else t
                                   for t in patch_dict[cname][psize]["results"]]
                           for psize in patch_dict[cname]}
                   for cname in patch_dict}
    with open(os.path.join(CHECKPOINT_PATH, "patch_results.json"), "w") as f:
        json.dump(result_dict, f, indent=4)
```

[16]:
```
def get_patches(class_names, patch_sizes):
    result_dict = dict()

    # Loop over all classes and patch sizes
    for name in class_names:
        result_dict[name] = dict()
        for patch_size in patch_sizes:
            c = label_names.index(name)
            file_name = os.path.join(CHECKPOINT_PATH, f"{name}_{patch_size}_patch.pt")
            # Load patch if pretrained file exists, otherwise start training
            if not os.path.isfile(file_name):
                patch, val_results = patch_attack(pretrained_model, target_class=c, patch_size=patch_size, num_epochs=5)
```

```
                print(f"Validation results for {name} and {patch_size}:",␣
↪val_results)
                torch.save(patch, file_name)
            else:
                patch = torch.load(file_name)
            # Load evaluation results if exist, otherwise manually evaluate the␣
↪patch
            if name in json_results:
                results = json_results[name][str(patch_size)]
            else:
                results = eval_patch(pretrained_model, patch, data_loader,␣
↪target_class=c)

            # Store results and the patches in a dict for better access
            result_dict[name][patch_size] = {
                "results": results,
                "patch": patch
            }

    return result_dict
```

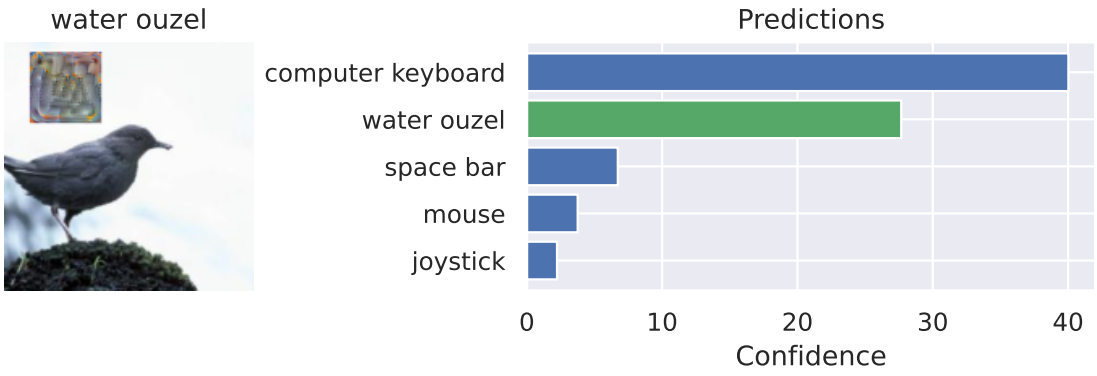
[ ]:
```
class_names = ['jackfruit', 'computer keyboard', 'sports car']
patch_sizes = [64]

patch_dict = get_patches(class_names, patch_sizes)
# save_results(patch_dict) # Uncomment if you add new class names and want to␣
↪save the new results
```

[18]:
```
def show_patches():
    fig, ax = plt.subplots(len(patch_sizes), len(class_names),␣
↪figsize=(len(class_names)*2.2, len(patch_sizes)*2.2))

    if len(patch_sizes) == 1 and len(class_names) == 1:
        # Single patch - ax is just one Axes object
        ax = np.array([[ax]])
    elif len(patch_sizes) == 1:
        # Single row - make it 2D
        ax = ax.reshape(1, -1)
    elif len(class_names) == 1:
        # Single column - make it 2D
        ax = ax.reshape(-1, 1)

    for c_idx, cname in enumerate(class_names):
        for p_idx, psize in enumerate(patch_sizes):
            patch = patch_dict[cname][psize]["patch"]
            patch = (torch.tanh(patch) + 1) / 2 # Parameter to pixel values
            patch = patch.cpu().permute(1, 2, 0).numpy()
```

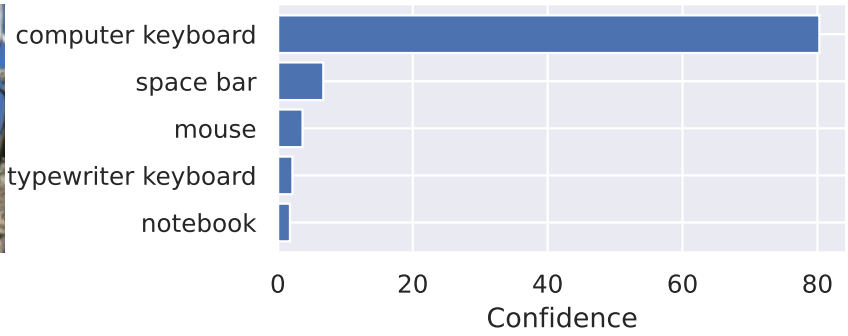
```
            patch = np.clip(patch, a_min=0.0, a_max=1.0)
            ax[p_idx][c_idx].imshow(patch)
            ax[p_idx][c_idx].set_title(f"{cname}, size {psize}")
            ax[p_idx][c_idx].axis('off')
    fig.subplots_adjust(hspace=0.5, wspace=0.5)
    plt.show()
show_patches()
```

[19]:
```
# Perform patch attack with computer keyboard patch
def perform_patch_attack(patch):
    patch_batch = exmp_batch.clone()
    patch_batch = place_patch(patch_batch, patch)
    with torch.no_grad():
        patch_preds = pretrained_model(patch_batch.to(device))
    for i in range(100,125,5):
        show_prediction(patch_batch[i], label_batch[i], patch_preds[i])
```

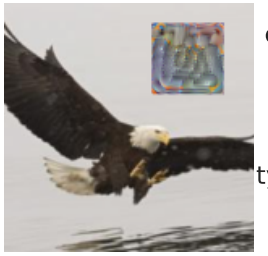
[20]:
```
perform_patch_attack(patch_dict['computer keyboard'][64]['patch'])
```

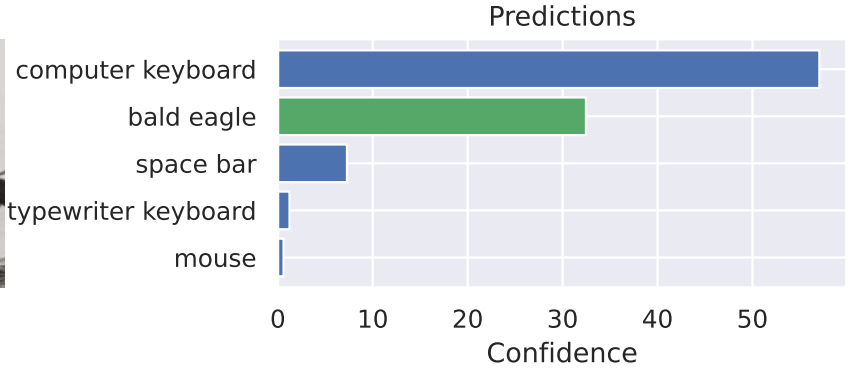


kite

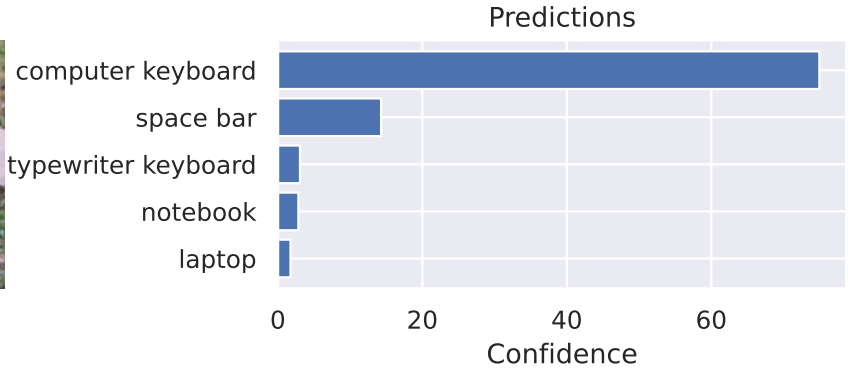


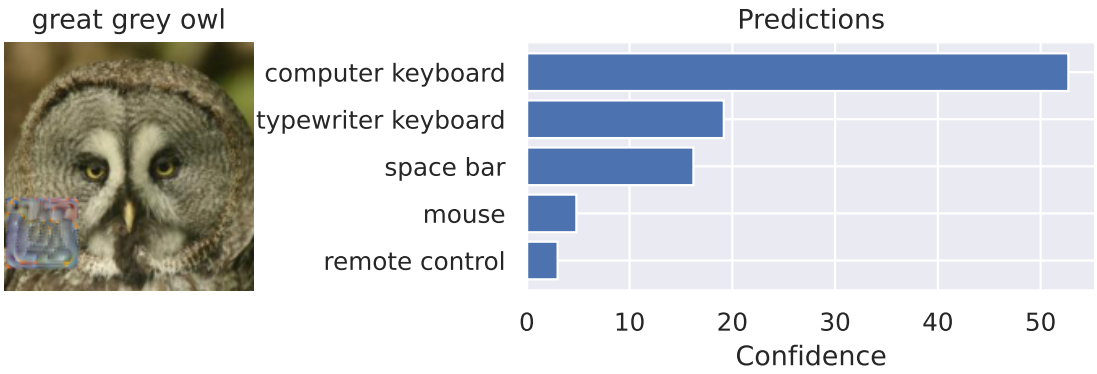
bald eagle





vulture



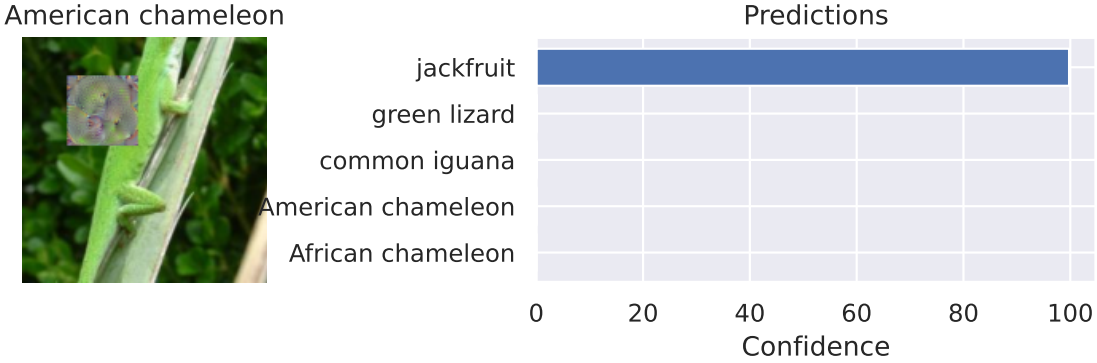


When we perform a patch attack using our computer keyboard patch, we mostly succeed in misleading the prediction. There is one exception with the bald eagle where the model still makes the correct prediction with a high confidence. The placement of the patch was randomized, so it is possible that for the bald eagle image, the patch covered an inessential feature of teh image. We can see that with the sucessful patch attacks, the patch covers most of the bird's body or an important feature such as their eye or wing.

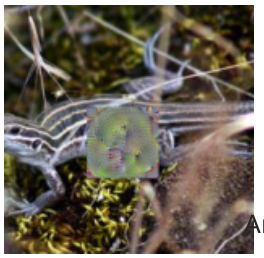
The image above is the result of the algorithm being executed a second time as I had to reset my notebook due to technical difficulties. We can see that the bald eagle no longer has the correct prediction as the top 1 prediction, which further shows that the placement of the patch could have an impact. In the very first run, the bald eagle had a correct prediction with a confidence near 50.

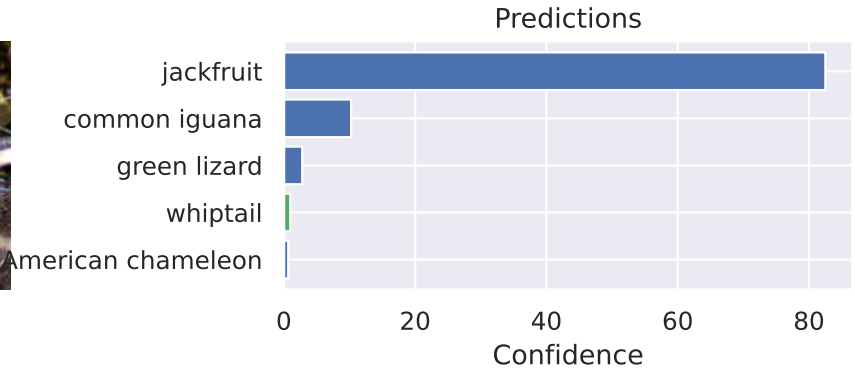
[21]:
```
# Perform patch attach with jackfruit patch with new images
def perform_patch_attack(patch):
    patch_batch = exmp_batch.clone()
    patch_batch = place_patch(patch_batch, patch)
    with torch.no_grad():
        patch_preds = pretrained_model(patch_batch.to(device))
    for i in range(200,225,5):
        show_prediction(patch_batch[i], label_batch[i], patch_preds[i])
```

[22]:
```
perform_patch_attack(patch_dict['jackfruit'][64]['patch'])
```

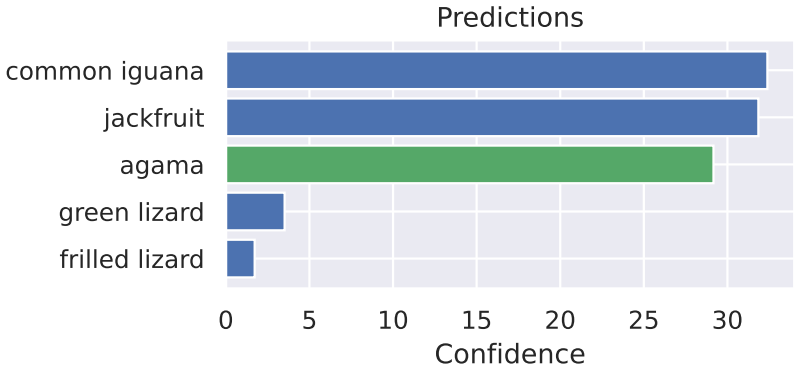


whiptail

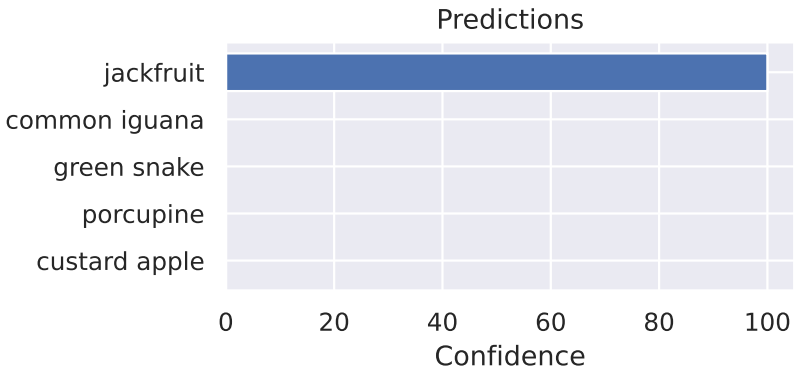


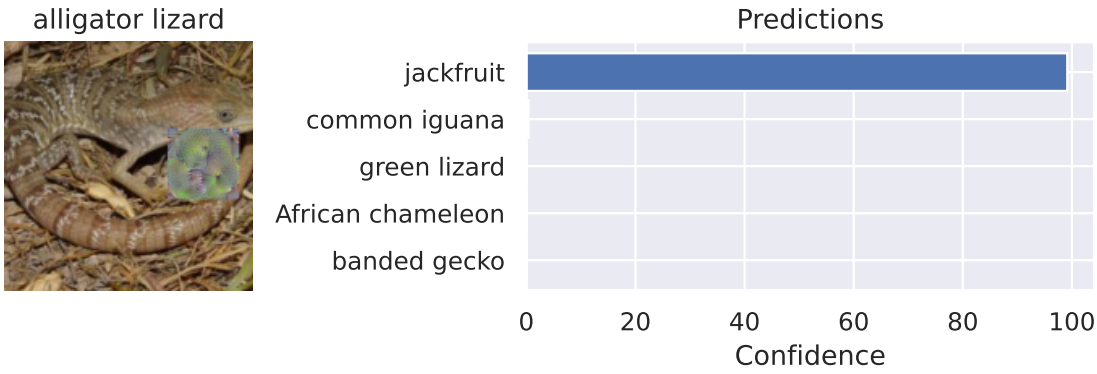


agama



frilled lizard

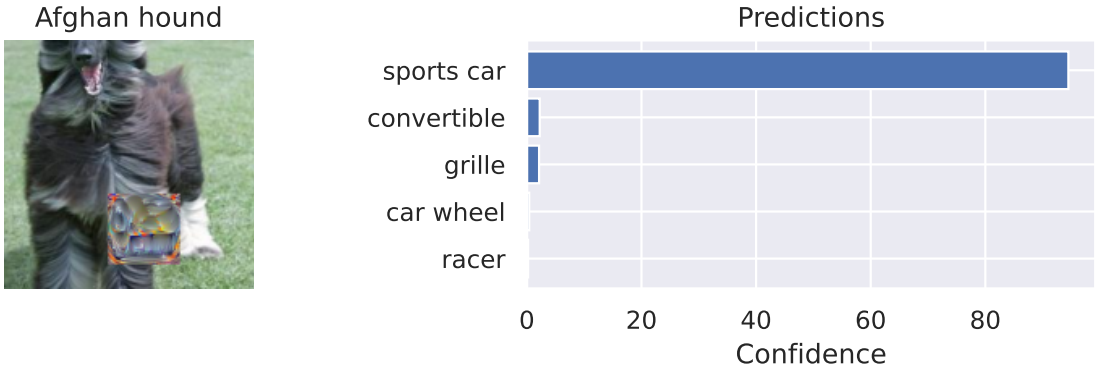




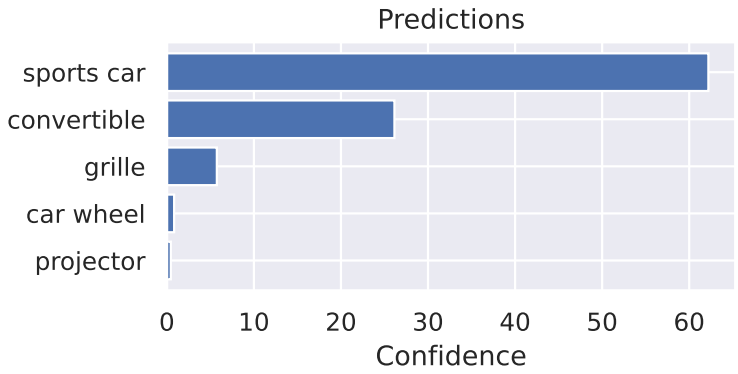
With the jackfruit patch, we see higher success in the patch attacks as there is 0 confidence for other predictions. In the previous example, we still noticed some confidence with other predictions within the top 5 predictions. Given the greenish color of the jackfruit patch, it also seems to blend in well with the images as most of the lizard series seem to have a greenish background.

[23]:
```
# Perform patch attack with sports car patch using new images
def perform_patch_attack(patch):
    patch_batch = exmp_batch.clone()
    patch_batch = place_patch(patch_batch, patch)
    with torch.no_grad():
        patch_preds = pretrained_model(patch_batch.to(device))
    for i in range(800,825,5):
        show_prediction(patch_batch[i], label_batch[i], patch_preds[i])
```

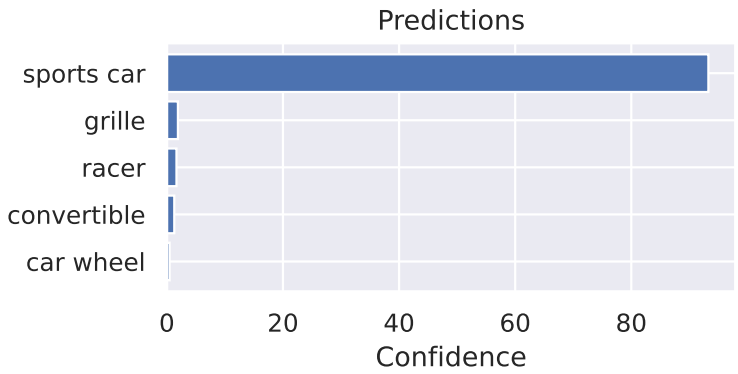
[24]:
```
perform_patch_attack(patch_dict['sports car'][64]['patch'])
```



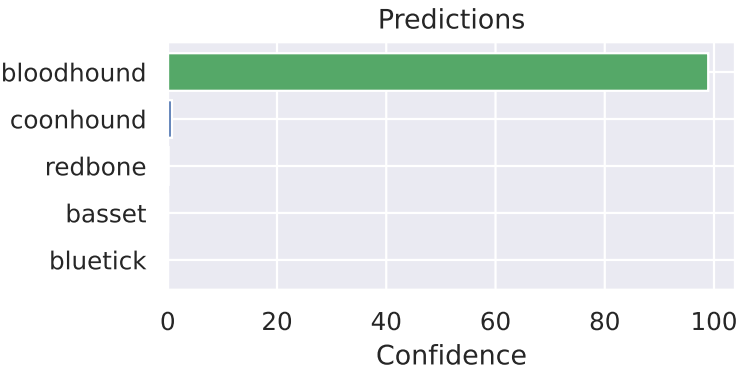
basset

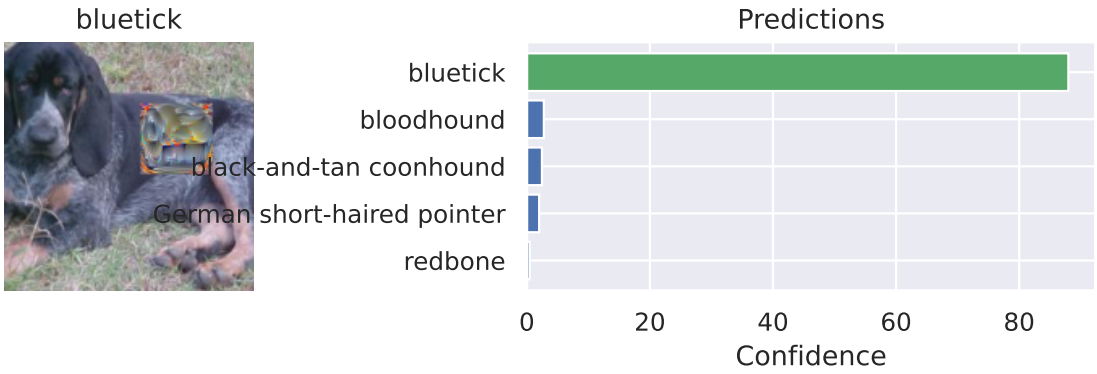


beagle



bloodhound

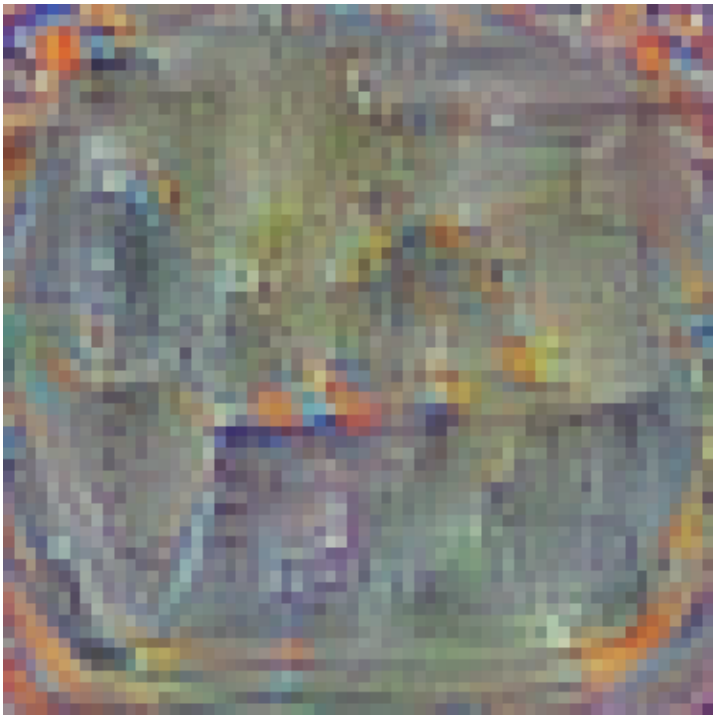




The sports car patch seems to perform the worst out of the 3. For the previous patches, the top 5 predictions would normally consist of similar species of the specific animal. However, here we notice that the top 5 predictions for some of the dogs have turned into car-related items which could indicate a stronger patch attack.

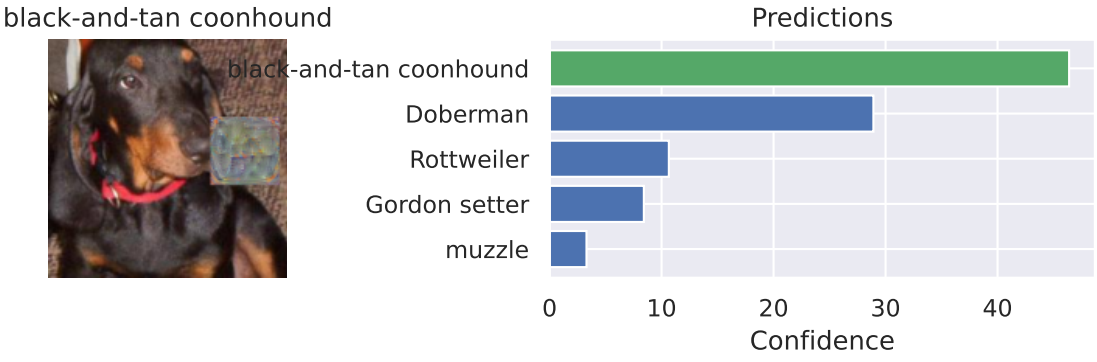
[25]:
```
# Combine 3 patches
patch1 = patch_dict['jackfruit'][64]['patch']
patch2 = patch_dict['computer keyboard'][64]['patch']
patch3 = patch_dict['sports car'][64]['patch']

combined_patch = (patch1 + patch2 + patch3) / 3

# Visualize
patch = (torch.tanh(combined_patch) + 1) / 2
patch = patch.cpu().permute(1, 2, 0).numpy()
patch = np.clip(patch, a_min=0.0, a_max=1.0)
plt.imshow(patch)
plt.title('Combined Patch, size 64')
plt.axis('off')
plt.show()
```

Combined Patch, size 64

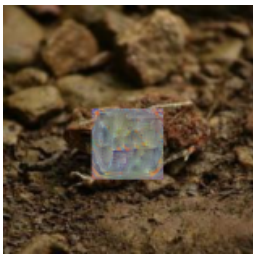


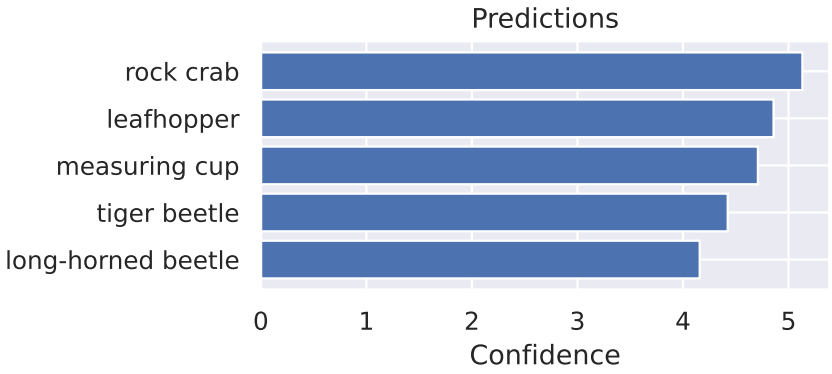
[42]:
```
# Perform patch attak with combined patch on random set of images
def perform_patch_attack(patch):
    patch_batch = exmp_batch.clone()
    patch_batch = place_patch(patch_batch, patch)
    with torch.no_grad():
        patch_preds = pretrained_model(patch_batch.to(device))
    random_idx = random.sample(range(1, 1000), 5)
    for i in random_idx:
        show_prediction(patch_batch[i], label_batch[i], patch_preds[i])
```

[43]:
```
perform_patch_attack(combined_patch)
```

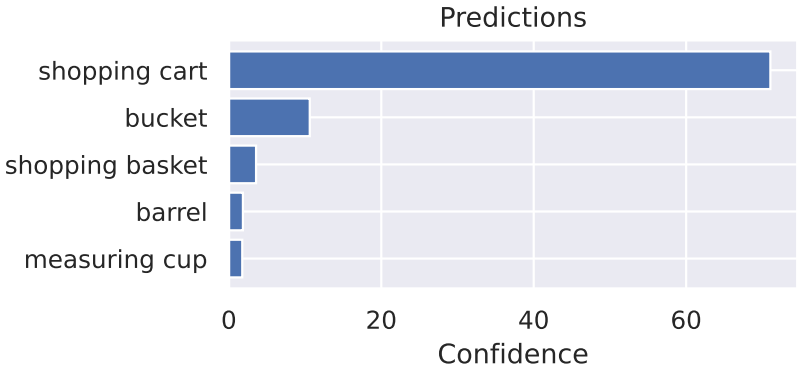


tailed frog

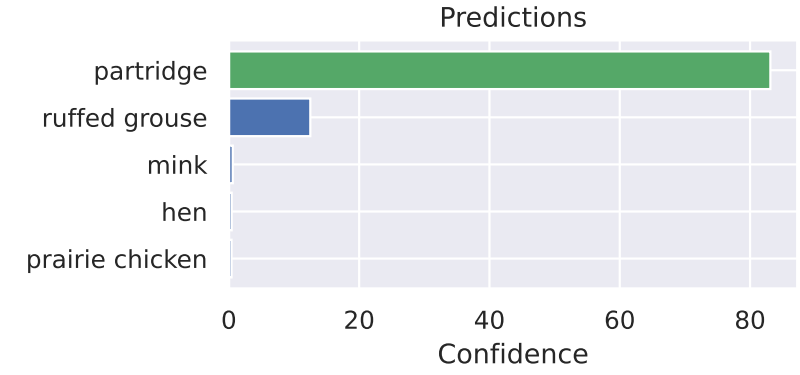


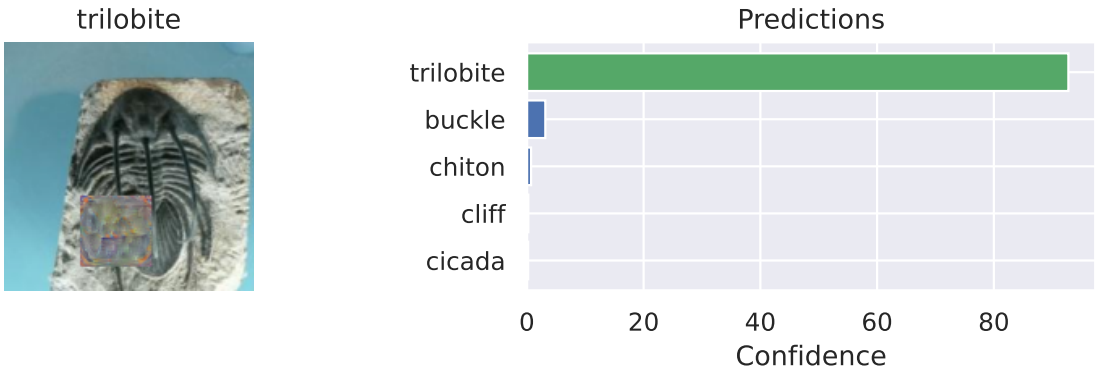


oystercatcher



partridge





When we combine all 3 patches into 1 patch, we noticed a significant drop in the performance. This is because when 3 patches try to "attack", the model gets confused about which patch to follow. As a result, the model may disregard the patch completely and focus on other parts of the images. This is why we see the model making correct predictions for several of the images. In other examples, we see the model making incorrect predictions with labels that were not part of the 3 patches. Combining 3 patches can blur out the original label they were trained for and create a whole new label. One interesting detail to note is that I ran several attacks on random subsets of the data, and "shopping cart" was a label that came up pretty often. A hypothesis is that by combining that patches for jackfruit, computer keyboard, and sports car, I created a whole new patch that tricks the model into predicting a shopping cart. The method I used to combine the patches was a simple blend. It's possible that if I use a different method such as weighted averages or using every other pixel, the results would've been different. The experiment of combining adversarial patches revealed that it may not always strengthen the attack but make it less effective instead. Additionally, it may lead to the creation of a patch with a new label.

[ ]:
```
!apt-get install -y texlive-xetex texlive-fonts-recommended texlive-latex-extra
```

```
Reading package lists… Done
Building dependency tree… Done
Reading state information… Done
The following additional packages will be installed:
  dvisvgm fonts-droid-fallback fonts-lato fonts-lmodern fonts-noto-mono
  fonts-texgyre fonts-urw-base35 libapache-pom-java libcommons-logging-java
  libcommons-parent-java libfontbox-java libgs9 libgs9-common libidn12
  libijs-0.35 libjbig2dec0 libkpathsea6 libpdfbox-java libptexenc1 libruby3.0
  libsynctex2 libteckit0 libtexlua53 libtexluajit2 libwoff1 libzzip-0-13
  lmodern poppler-data preview-latex-style rake ruby ruby-net-telnet
  ruby-rubygems ruby-webrick ruby-xmlrpc ruby3.0 rubygems-integration t1utils
  teckit tex-common tex-gyre texlive-base texlive-binaries texlive-latex-base
  texlive-latex-recommended texlive-pictures texlive-plain-generic tipa
  xfonts-encodings xfonts-utils
Suggested packages:
  fonts-noto fonts-freefont-otf | fonts-freefont-ttf libavalon-framework-java
  libcommons-logging-java-doc libexcalibur-logkit-java liblog4j1.2-java
```

```
  poppler-utils ghostscript fonts-japanese-mincho | fonts-ipafont-mincho
  fonts-japanese-gothic | fonts-ipafont-gothic fonts-arphic-ukai
  fonts-arphic-uming fonts-nanum ri ruby-dev bundler debhelper gv
  | postscript-viewer perl-tk xpdf | pdf-viewer xzdec
  texlive-fonts-recommended-doc texlive-latex-base-doc python3-pygments
  icc-profiles libfile-which-perl libspreadsheet-parseexcel-perl
  texlive-latex-extra-doc texlive-latex-recommended-doc texlive-luatex
  texlive-pstricks dot2tex prerex texlive-pictures-doc vprerex
  default-jre-headless tipa-doc
The following NEW packages will be installed:
  dvisvgm fonts-droid-fallback fonts-lato fonts-lmodern fonts-noto-mono
  fonts-texgyre fonts-urw-base35 libapache-pom-java libcommons-logging-java
  libcommons-parent-java libfontbox-java libgs9 libgs9-common libidn12
  libijs-0.35 libjbig2dec0 libkpathsea6 libpdfbox-java libptexenc1 libruby3.0
  libsynctex2 libteckit0 libtexlua53 libtexluajit2 libwoff1 libzzip-0-13
  lmodern poppler-data preview-latex-style rake ruby ruby-net-telnet
  ruby-rubygems ruby-webrick ruby-xmlrpc ruby3.0 rubygems-integration t1utils
  teckit tex-common tex-gyre texlive-base texlive-binaries
  texlive-fonts-recommended texlive-latex-base texlive-latex-extra
  texlive-latex-recommended texlive-pictures texlive-plain-generic
  texlive-xetex tipa xfonts-encodings xfonts-utils
0 upgraded, 53 newly installed, 0 to remove and 41 not upgraded.
Need to get 182 MB of archives.
After this operation, 571 MB of additional disk space will be used.
Get:1 http://archive.ubuntu.com/ubuntu jammy/main amd64 fonts-droid-fallback all
1:6.0.1r16-1.1build1 [1,805 kB]
Get:2 http://archive.ubuntu.com/ubuntu jammy/main amd64 fonts-lato all 2.0-2.1
[2,696 kB]
Get:3 http://archive.ubuntu.com/ubuntu jammy/main amd64 poppler-data all
0.4.11-1 [2,171 kB]
Get:4 http://archive.ubuntu.com/ubuntu jammy/universe amd64 tex-common all 6.17
[33.7 kB]
Get:5 http://archive.ubuntu.com/ubuntu jammy/main amd64 fonts-urw-base35 all
20200910-1 [6,367 kB]
Get:6 http://archive.ubuntu.com/ubuntu jammy-updates/main amd64 libgs9-common
all 9.55.0~dfsg1-0ubuntu5.13 [753 kB]
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1.38-4ubuntu1 [60.0 kB]
Get:8 http://archive.ubuntu.com/ubuntu jammy/main amd64 libijs-0.35 amd64
0.35-15build2 [16.5 kB]
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0.19-3build2 [64.7 kB]
Get:10 http://archive.ubuntu.com/ubuntu jammy-updates/main amd64 libgs9 amd64
9.55.0~dfsg1-0ubuntu5.13 [5,032 kB]
Get:11 http://archive.ubuntu.com/ubuntu jammy-updates/main amd64 libkpathsea6
amd64 2021.20210626.59705-1ubuntu0.2 [60.4 kB]
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1.0.2-1build4 [45.2 kB]
```

```
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2.004.5-6.1 [4,532 kB]
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20201225-1build1 [397 kB]
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20180621-3.1 [10.2 MB]
Get:17 http://archive.ubuntu.com/ubuntu jammy/universe amd64 libapache-pom-java
all 18-1 [4,720 B]
Get:18 http://archive.ubuntu.com/ubuntu jammy/universe amd64 libcommons-parent-
java all 43-1 [10.8 kB]
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java all 1.2-2 [60.3 kB]
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amd64 2021.20210626.59705-1ubuntu0.2 [39.1 kB]
Get:21 http://archive.ubuntu.com/ubuntu jammy/main amd64 rubygems-integration
all 1.18 [5,336 B]
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3.0.2-7ubuntu2.11 [50.1 kB]
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all 3.3.5-2ubuntu1.2 [228 kB]
Get:24 http://archive.ubuntu.com/ubuntu jammy/main amd64 ruby amd64 1:3.0~exp1
[5,100 B]
Get:25 http://archive.ubuntu.com/ubuntu jammy/main amd64 rake all 13.0.6-2 [61.7
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amd64 3.0.2-7ubuntu2.11 [5,114 kB]
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1:1.0.5-0ubuntu2 [578 kB]
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1:7.7+6build2 [94.6 kB]
```

```
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2.004.5-6.1 [9,471 kB]
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all 12.2-1ubuntu1 [185 kB]
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1.41-4build2 [61.3 kB]
Get:40 http://archive.ubuntu.com/ubuntu jammy/universe amd64 teckit amd64
2.5.11+ds1-1 [699 kB]
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20180621-3.1 [6,209 kB]
Get:42 http://archive.ubuntu.com/ubuntu jammy-updates/universe amd64 texlive-
binaries amd64 2021.20210626.59705-1ubuntu0.2 [9,860 kB]
Get:43 http://archive.ubuntu.com/ubuntu jammy/universe amd64 texlive-base all
2021.20220204-1 [21.0 MB]
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recommended all 2021.20220204-1 [4,972 kB]
Get:45 http://archive.ubuntu.com/ubuntu jammy/universe amd64 texlive-latex-base
all 2021.20220204-1 [1,128 kB]
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1:1.8.16-2 [207 kB]
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all 2021.20220204-1 [13.9 MB]
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generic all 2021.20220204-1 [27.5 MB]
Get:52 http://archive.ubuntu.com/ubuntu jammy/universe amd64 tipa all 2:1.3-21
[2,967 kB]
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2021.20220204-1 [12.4 MB]
Fetched 182 MB in 8s (22.5 MB/s)
Extracting templates from packages: 100%
Preconfiguring packages …
Selecting previously unselected package fonts-droid-fallback.
(Reading database … 125080 files and directories currently installed.)
Preparing to unpack …/00-fonts-droid-fallback_1%3a6.0.1r16-1.1build1_all.deb
…
Unpacking fonts-droid-fallback (1:6.0.1r16-1.1build1) …
Selecting previously unselected package fonts-lato.
Preparing to unpack …/01-fonts-lato_2.0-2.1_all.deb …
Unpacking fonts-lato (2.0-2.1) …
Selecting previously unselected package poppler-data.
Preparing to unpack …/02-poppler-data_0.4.11-1_all.deb …
Unpacking poppler-data (0.4.11-1) …
```

```
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Selecting previously unselected package fonts-urw-base35.
Preparing to unpack …/04-fonts-urw-base35_20200910-1_all.deb …
Unpacking fonts-urw-base35 (20200910-1) …
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Selecting previously unselected package libidn12:amd64.
Preparing to unpack …/06-libidn12_1.38-4ubuntu1_amd64.deb …
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Selecting previously unselected package libijs-0.35:amd64.
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Unpacking libjbig2dec0:amd64 (0.19-3build2) …
Selecting previously unselected package libgs9:amd64.
Preparing to unpack …/09-libgs9_9.55.0~dfsg1-0ubuntu5.13_amd64.deb …
Unpacking libgs9:amd64 (9.55.0~dfsg1-0ubuntu5.13) …
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…
Unpacking libkpathsea6:amd64 (2021.20210626.59705-1ubuntu0.2) …
Selecting previously unselected package libwoff1:amd64.
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Unpacking dvisvgm (2.13.1-1) …
Selecting previously unselected package fonts-lmodern.
Preparing to unpack …/13-fonts-lmodern_2.004.5-6.1_all.deb …
Unpacking fonts-lmodern (2.004.5-6.1) …
Selecting previously unselected package fonts-noto-mono.
Preparing to unpack …/14-fonts-noto-mono_20201225-1build1_all.deb …
Unpacking fonts-noto-mono (20201225-1build1) …
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Preparing to unpack …/15-fonts-texgyre_20180621-3.1_all.deb …
Unpacking fonts-texgyre (20180621-3.1) …
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Preparing to unpack …/16-libapache-pom-java_18-1_all.deb …
Unpacking libapache-pom-java (18-1) …
Selecting previously unselected package libcommons-parent-java.
Preparing to unpack …/17-libcommons-parent-java_43-1_all.deb …
Unpacking libcommons-parent-java (43-1) …
Selecting previously unselected package libcommons-logging-java.
Preparing to unpack …/18-libcommons-logging-java_1.2-2_all.deb …
```

```
Unpacking libcommons-logging-java (1.2-2) …
Selecting previously unselected package libptexenc1:amd64.
Preparing to unpack …/19-libptexenc1_2021.20210626.59705-1ubuntu0.2_amd64.deb
…
Unpacking libptexenc1:amd64 (2021.20210626.59705-1ubuntu0.2) …
Selecting previously unselected package rubygems-integration.
Preparing to unpack …/20-rubygems-integration_1.18_all.deb …
Unpacking rubygems-integration (1.18) …
Selecting previously unselected package ruby3.0.
Preparing to unpack …/21-ruby3.0_3.0.2-7ubuntu2.11_amd64.deb …
Unpacking ruby3.0 (3.0.2-7ubuntu2.11) …
Selecting previously unselected package ruby-rubygems.
Preparing to unpack …/22-ruby-rubygems_3.3.5-2ubuntu1.2_all.deb …
Unpacking ruby-rubygems (3.3.5-2ubuntu1.2) …
Selecting previously unselected package ruby.
Preparing to unpack …/23-ruby_1%3a3.0~exp1_amd64.deb …
Unpacking ruby (1:3.0~exp1) …
Selecting previously unselected package rake.
Preparing to unpack …/24-rake_13.0.6-2_all.deb …
Unpacking rake (13.0.6-2) …
Selecting previously unselected package ruby-net-telnet.
Preparing to unpack …/25-ruby-net-telnet_0.1.1-2_all.deb …
Unpacking ruby-net-telnet (0.1.1-2) …
Selecting previously unselected package ruby-webrick.
Preparing to unpack …/26-ruby-webrick_1.7.0-3ubuntu0.2_all.deb …
Unpacking ruby-webrick (1.7.0-3ubuntu0.2) …
Selecting previously unselected package ruby-xmlrpc.
Preparing to unpack …/27-ruby-xmlrpc_0.3.2-1ubuntu0.1_all.deb …
Unpacking ruby-xmlrpc (0.3.2-1ubuntu0.1) …
Selecting previously unselected package libruby3.0:amd64.
Preparing to unpack …/28-libruby3.0_3.0.2-7ubuntu2.11_amd64.deb …
Unpacking libruby3.0:amd64 (3.0.2-7ubuntu2.11) …
Selecting previously unselected package libsynctex2:amd64.
Preparing to unpack …/29-libsynctex2_2021.20210626.59705-1ubuntu0.2_amd64.deb
…
Unpacking libsynctex2:amd64 (2021.20210626.59705-1ubuntu0.2) …
Selecting previously unselected package libteckit0:amd64.
Preparing to unpack …/30-libteckit0_2.5.11+ds1-1_amd64.deb …
Unpacking libteckit0:amd64 (2.5.11+ds1-1) …
Selecting previously unselected package libtexlua53:amd64.
Preparing to unpack …/31-libtexlua53_2021.20210626.59705-1ubuntu0.2_amd64.deb
…
Unpacking libtexlua53:amd64 (2021.20210626.59705-1ubuntu0.2) …
Selecting previously unselected package libtexluajit2:amd64.
Preparing to unpack
…/32-libtexluajit2_2021.20210626.59705-1ubuntu0.2_amd64.deb …
Unpacking libtexluajit2:amd64 (2021.20210626.59705-1ubuntu0.2) …
Selecting previously unselected package libzzip-0-13:amd64.
```

```
Preparing to unpack …/33-libzzip-0-13_0.13.72+dfsg.1-1.1_amd64.deb …
Unpacking libzzip-0-13:amd64 (0.13.72+dfsg.1-1.1) …
Selecting previously unselected package xfonts-encodings.
Preparing to unpack …/34-xfonts-encodings_1%3a1.0.5-0ubuntu2_all.deb …
Unpacking xfonts-encodings (1:1.0.5-0ubuntu2) …
Selecting previously unselected package xfonts-utils.
Preparing to unpack …/35-xfonts-utils_1%3a7.7+6build2_amd64.deb …
Unpacking xfonts-utils (1:7.7+6build2) …
Selecting previously unselected package lmodern.
Preparing to unpack …/36-lmodern_2.004.5-6.1_all.deb …
Unpacking lmodern (2.004.5-6.1) …
Selecting previously unselected package preview-latex-style.
Preparing to unpack …/37-preview-latex-style_12.2-1ubuntu1_all.deb …
Unpacking preview-latex-style (12.2-1ubuntu1) …
Selecting previously unselected package t1utils.
Preparing to unpack …/38-t1utils_1.41-4build2_amd64.deb …
Unpacking t1utils (1.41-4build2) …
Selecting previously unselected package teckit.
Preparing to unpack …/39-teckit_2.5.11+ds1-1_amd64.deb …
Unpacking teckit (2.5.11+ds1-1) …
Selecting previously unselected package tex-gyre.
Preparing to unpack …/40-tex-gyre_20180621-3.1_all.deb …
Unpacking tex-gyre (20180621-3.1) …
Selecting previously unselected package texlive-binaries.
Preparing to unpack …/41-texlive-
binaries_2021.20210626.59705-1ubuntu0.2_amd64.deb …
Unpacking texlive-binaries (2021.20210626.59705-1ubuntu0.2) …
Selecting previously unselected package texlive-base.
Preparing to unpack …/42-texlive-base_2021.20220204-1_all.deb …
Unpacking texlive-base (2021.20220204-1) …
Selecting previously unselected package texlive-fonts-recommended.
Preparing to unpack …/43-texlive-fonts-recommended_2021.20220204-1_all.deb …
Unpacking texlive-fonts-recommended (2021.20220204-1) …
Selecting previously unselected package texlive-latex-base.
Preparing to unpack …/44-texlive-latex-base_2021.20220204-1_all.deb …
Unpacking texlive-latex-base (2021.20220204-1) …
Selecting previously unselected package libfontbox-java.
Preparing to unpack …/45-libfontbox-java_1%3a1.8.16-2_all.deb …
Unpacking libfontbox-java (1:1.8.16-2) …
Selecting previously unselected package libpdfbox-java.
Preparing to unpack …/46-libpdfbox-java_1%3a1.8.16-2_all.deb …
Unpacking libpdfbox-java (1:1.8.16-2) …
Selecting previously unselected package texlive-latex-recommended.
Preparing to unpack …/47-texlive-latex-recommended_2021.20220204-1_all.deb …
Unpacking texlive-latex-recommended (2021.20220204-1) …
Selecting previously unselected package texlive-pictures.
Preparing to unpack …/48-texlive-pictures_2021.20220204-1_all.deb …
Unpacking texlive-pictures (2021.20220204-1) …
```

```
Selecting previously unselected package texlive-latex-extra.
Preparing to unpack …/49-texlive-latex-extra_2021.20220204-1_all.deb …
Unpacking texlive-latex-extra (2021.20220204-1) …
```

[46]:
```
!jupyter nbconvert --to pdf "/content/drive/MyDrive/Colab Notebooks/
↪adversarial_patches_Jin.ipynb"
```

```
[NbConvertApp] Converting notebook /content/drive/MyDrive/Colab
Notebooks/adversarial_patches_Jin.ipynb to pdf
[NbConvertApp] Support files will be in adversarial_patches_Jin_files/
[NbConvertApp] Making directory ./adversarial_patches_Jin_files
[NbConvertApp] Writing 99642 bytes to notebook.tex
[NbConvertApp] Building PDF
Traceback (most recent call last):
  File "/usr/local/bin/jupyter-nbconvert", line 10, in <module>
    sys.exit(main())
             ^^^^^^
  File "/usr/local/lib/python3.12/dist-packages/jupyter_core/application.py",
line 284, in launch_instance
    super().launch_instance(argv=argv, **kwargs)
  File "/usr/local/lib/python3.12/dist-
packages/traitlets/config/application.py", line 992, in launch_instance
    app.start()
  File "/usr/local/lib/python3.12/dist-packages/nbconvert/nbconvertapp.py", line
420, in start
    self.convert_notebooks()
  File "/usr/local/lib/python3.12/dist-packages/nbconvert/nbconvertapp.py", line
597, in convert_notebooks
    self.convert_single_notebook(notebook_filename)
  File "/usr/local/lib/python3.12/dist-packages/nbconvert/nbconvertapp.py", line
563, in convert_single_notebook
    output, resources = self.export_single_notebook(
                        ^^^^^^^^^^^^^^^^^^^^^^^^^^^^
  File "/usr/local/lib/python3.12/dist-packages/nbconvert/nbconvertapp.py", line
487, in export_single_notebook
    output, resources = self.exporter.from_filename(
                        ^^^^^^^^^^^^^^^^^^^^^^^^^^^^
  File "/usr/local/lib/python3.12/dist-
packages/nbconvert/exporters/templateexporter.py", line 390, in from_filename
    return super().from_filename(filename, resources, **kw)  #
type:ignore[return-value]
           ^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^
  File "/usr/local/lib/python3.12/dist-
packages/nbconvert/exporters/exporter.py", line 201, in from_filename
    return self.from_file(f, resources=resources, **kw)
           ^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^
  File "/usr/local/lib/python3.12/dist-
packages/nbconvert/exporters/templateexporter.py", line 396, in from_file
```

```
    return super().from_file(file_stream, resources, **kw)  #
type:ignore[return-value]
           ^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^
  File "/usr/local/lib/python3.12/dist-
packages/nbconvert/exporters/exporter.py", line 220, in from_file
    return self.from_notebook_node(
           ^^^^^^^^^^^^^^^^^^^^^^^^
  File "/usr/local/lib/python3.12/dist-packages/nbconvert/exporters/pdf.py",
line 197, in from_notebook_node
    self.run_latex(tex_file)
  File "/usr/local/lib/python3.12/dist-packages/nbconvert/exporters/pdf.py",
line 166, in run_latex
    return self.run_command(
           ^^^^^^^^^^^^^^^^^
  File "/usr/local/lib/python3.12/dist-packages/nbconvert/exporters/pdf.py",
line 120, in run_command
    raise OSError(msg)
OSError: xelatex not found on PATH, if you have not installed xelatex you may
need to do so. Find further instructions at
https://nbconvert.readthedocs.io/en/latest/install.html#installing-tex.
```