ResNet-Grad-Cam

May 27, 2020

[1]:

```
import torch
from torchvision import datasets, transforms as T
from torch.utils.data import DataLoader, TensorDataset
from torch import nn
import torchvision.models as models
from matplotlib import pyplot
import numpy as np
import json
import cv2 as cv
import torch.nn.functional as F

normalize = T.Normalize(mean=[0.485, 0.456, 0.406],
                        std=[0.229, 0.224, 0.225])
#load ImageNet validation data
transform = T.Compose([T.Resize((224, 224)),
                       T.ToTensor()
                       #normalize
                      ])

#input image
input_image = datasets.ImageFolder(root='/home/jason/Documents/Uni/
 ↪multimedia_project/multimedia_project/data/',
                               transform=transform)

#y labels
filepath = 'ILSVRC2015_clsloc_validation_ground_truth.txt'

def get_valid_label(filepath):
    label_list = []
    with open(filepath, 'r') as f:
        ctx = f.readlines()
        for tmp in ctx:
            label_list.append(int(tmp.rstrip('\n')))

    return label_list

y = get_valid_label(filepath)
```

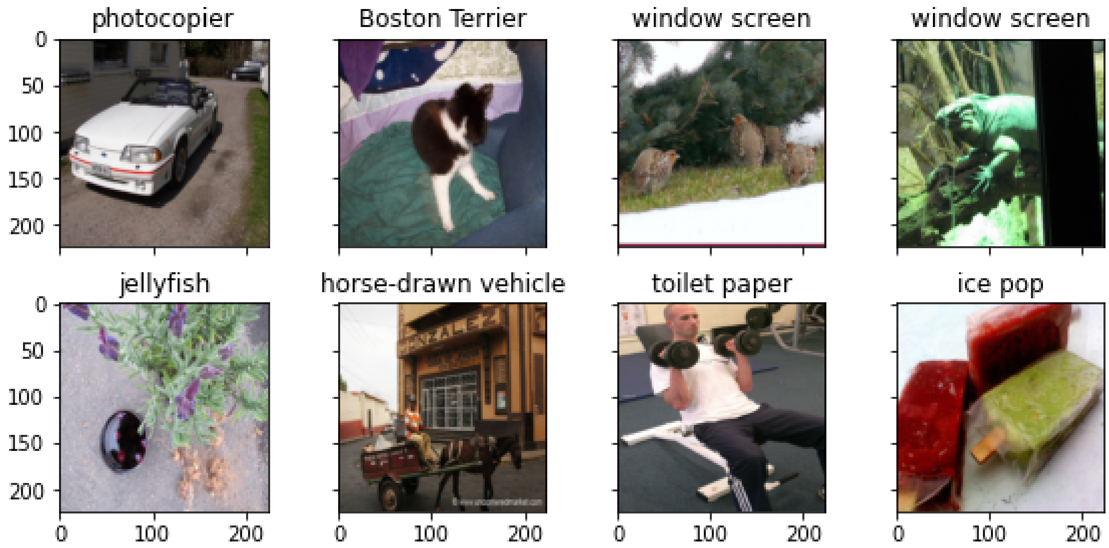
```
testloader = DataLoader(input_image, batch_size=1, shuffle=True, num_workers=2)

#load imagenet label
with open('labels.json') as f:
    label = json.load(f)
    f.close()
```

[2]:

```
#image plot help function
def plot_multiple(images, titles, colormap='gray', max_columns=np.inf, share_axes=True):
    """Plot multiple images as subplots on a grid."""
    assert len(images) == len(titles)
    n_images = len(images)
    n_cols = min(max_columns, n_images)
    n_rows = int(np.ceil(n_images / n_cols))
    fig, axes = pyplot.subplots(
        n_rows, n_cols, figsize=(n_cols * 2, n_rows * 2),
        squeeze=False, sharex=share_axes, sharey=share_axes)

    axes = axes.flat
    # Hide subplots without content
    for ax in axes[n_images:]:
        ax.axis('off')

    if not isinstance(colormap, (list,tuple)):
        colormaps = [colormap]*n_images
    else:
        colormaps = colormap

    for ax, image, title, cmap in zip(axes, images, titles, colormaps):
        ax.imshow(image, cmap=cmap)
        ax.set_title(title)

    fig.tight_layout()
```

[3]:

```
#import pre trained model
model = models.resnet18(pretrained=True)
#set the model to evaluate mode
model.eval()

def predict_image(num=8, coloum = 4):
    titles = []
    images = []
    for _ in range(num):
        image = iter(testloader).next()
        x = model(image[0])
        result = torch.argmax(x)
        npimg = np.array(image[0]).squeeze()
        images.append(np.transpose(npimg, (1, 2, 0)))
        titles.append(label[result])
    plot_multiple(images, titles, max_columns=4)
predict_image()
```



[4]:
```
def generate_random_image():
    image = iter(testloader).next()
    return image[0]

def saliency_detection_function(image):
    saliency = cv.saliency.StaticSaliencySpectralResidual_create()
    (success, saliencyMap) = saliency.computeSaliency(image)
    saliencyMap = (saliencyMap * 255).astype("uint8")
    return saliencyMap
```

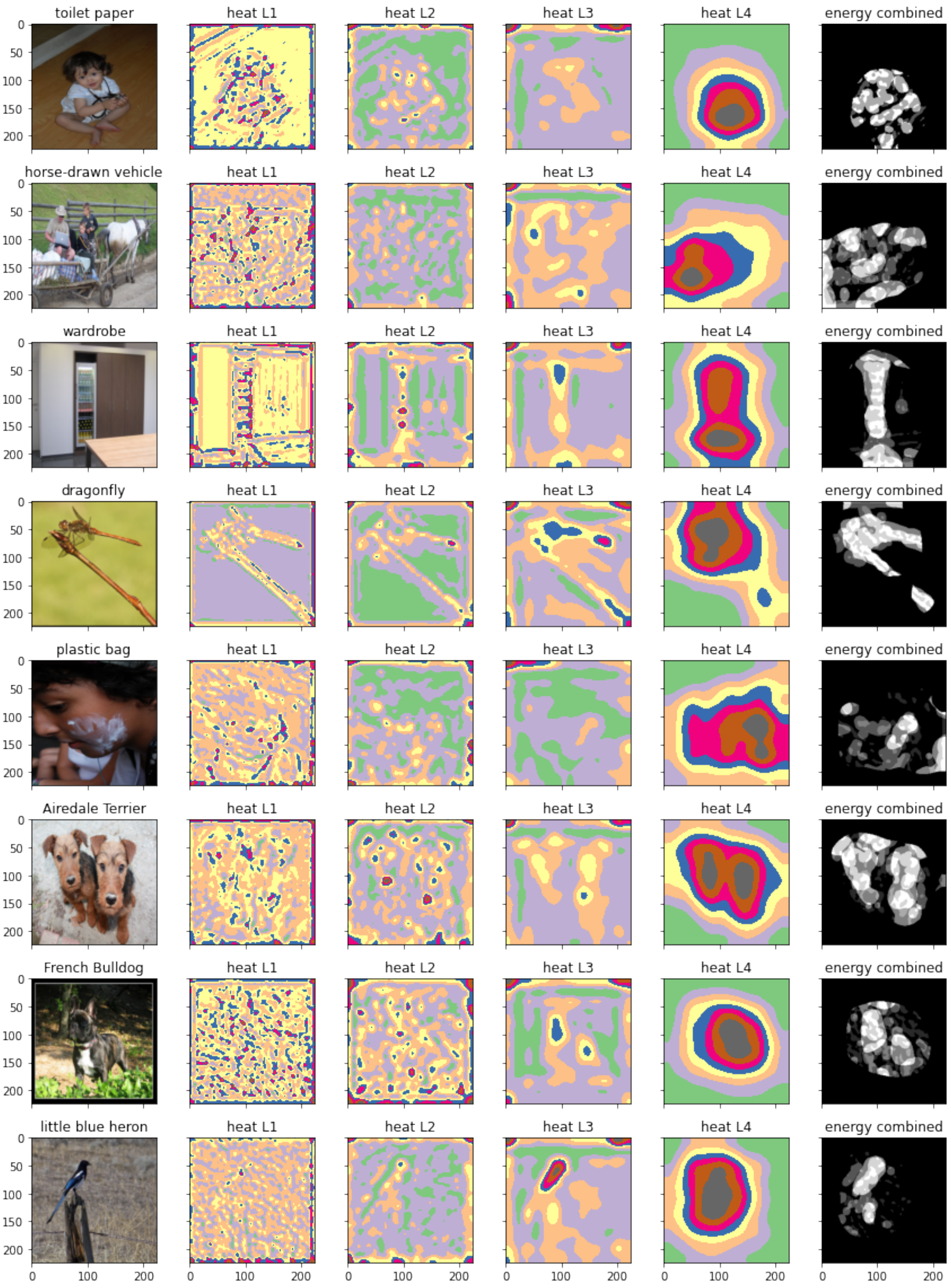
[5]:
```
# output original image list and heatmap image list
def generate_heat_map_image(model, saliency=True):
    #get the gradient value by using hook
    gradList = []
    featureList = []

    #using grad hook and feature hook to get gradient and feature map
    def gradhook(module, grad_input, grad_output):
        gradList.append(grad_output[0])

    def featurehook(module, i, o):
```

```
    featureList.append(o[0])

#connect hook function to each layers
for layerIdx in range(1, 5):
    #link the hook back the model to the specific layer
    getattr(model,"layer"+str(layerIdx)).register_backward_hook(gradhook)
    getattr(model,"layer"+str(layerIdx)).register_forward_hook(featurehook)

#get a random image
image = generate_random_image()
out = model(image)
result = torch.argmax(out)
title = label[result]
loss = torch.sum(F.log_softmax(out, -1), -1)
mean_loss = loss.mean()

#generate the gradient via back propagation
mean_loss.backward()

#covert to numpy image
npimg = np.array(image).squeeze()
originimg = np.transpose(npimg, (1, 2, 0))

heatmapList = []
#calculate the weight of global average pooling of the gradient
for layerIdx in range(1, 5):
    a = gradList[layerIdx-1].squeeze()
    a = torch.nn.functional.max_pool2d(a, a.shape[1]) # weight

    #normalize weight and apply relu as activatiom map
    weight = a / torch.sum(a)
    weight = torch.nn.functional.relu(weight)
    weight = weight.detach().numpy().squeeze()
    feature = featureList[layerIdx-1].detach().numpy()

    #generate the heatmap
    heatmap = np.zeros_like(feature[0])
    for coef, tmp in zip(weight, feature):
        heatmap += tmp*coef
    heatmap = heatmap * 255
    heatmap = cv.resize(heatmap, (224, 224), interpolation=cv.INTER_CUBIC)

    #bin equalization to adjust the contrast ratio
    lowerbound = heatmap.min()
    higherbound = heatmap.max()
    totalRange = higherbound - lowerbound
    heatmap = (heatmap - lowerbound) / totalRange * 255
```

```
        #covert the color map
        heatmap = heatmap.astype(np.uint8)
        #implemented saliency map
        if saliency:
            heatmap = saliency_detection_function(heatmap)
        heatmapList.append(heatmap)

    return originimg, heatmapList, title
```

[8]:

```
def ostu_energy_function(imgList):
    tmpList = []
    for tmpIg in imgList:
        blur = cv.GaussianBlur(tmpIg,(5,5),0)
        _,heatmap = cv.threshold(blur,0,255,cv.THRESH_BINARY+cv.THRESH_OTSU)
        tmpList.append(heatmap)
    dilatation_size = 4
    element = cv.getStructuringElement(cv.MORPH_ELLIPSE, (2*dilatation_size +␣
 ↪1, 2*dilatation_size+1), (dilatation_size, dilatation_size))
    tmpList[1] = cv.dilate(tmpList[1], element)
    tmpList[2] = cv.dilate(tmpList[2], element)

    imageholder = np.zeros_like(tmpList[0])
    imageholder = tmpList[0] * tmpList[-1] * 1 + tmpList[1] * tmpList[-1] * 2 +␣
 ↪tmpList[2] * tmpList[-1]*3
    imageholder = (imageholder - imageholder.min())/imageholder.max()
    return imageholder

def plot_result(num=6):
    imglist = []
    titlelist = []
    cmaplist = []
    outputtitle = []
    for idx in range(8):
        img, heatmapList, title = generate_heat_map_image(model, False)
        combined = ostu_energy_function(heatmapList)
        imglist = imglist + [img] + heatmapList + [combined]

        titlelist = titlelist + [title, 'heat L1', 'heat L2', 'heat L3', 'heat␣
 ↪L4', 'energy combined']
        cmaplist.append('gray')
        cmaplist += ['Accent'] * 4
        cmaplist += ['gray']

        pyplot.imsave('./{}-{}'.format(idx, 'origin.jpg'), img)

        for nameIdx in range(1, 5):
            pyplot.imsave('./{}-{}'.format(idx, 'heat' + str(nameIdx) +'.jpg'),␣
 ↪heatmapList[nameIdx-1], cmap='Accent')
        outputtitle.append(title)
    plot_multiple(imglist, titlelist, cmaplist, num)
    return outputtitle
titlelist = plot_result()
```



[7]:

```
def plot_merge_heatmap(titlelist):
    outputlist = []
```

```python
imglist = []
for idx in range(8):
    #define path
    oripath = './{}-{}'.format(idx, 'origin.jpg')
    heatpath = './{}-{}'.format(idx, 'heat3.jpg')

    #get original image
    ori = cv.imread(oripath, cv.IMREAD_COLOR)
    tmp_ori = cv.cvtColor(ori, cv.COLOR_RGB2BGR)
    imglist.append(tmp_ori)
    outputlist.append('{}'.format(titlelist[idx]))


    #get combined image
    heat = cv.imread(heatpath, cv.IMREAD_COLOR)
    heat_tmp = cv.cvtColor(heat, cv.COLOR_RGB2BGR)
    imglist.append(heat_tmp)
    outputlist.append('{}'.format('heatmap'))

    cv.addWeighted(ori, 0.5, heat, 0.5, 0, heat)
    combinedpath = './{}-{}'.format(idx, 'combined.jpg')
    cv.imwrite(combinedpath, heat)
    tmp = cv.cvtColor(heat, cv.COLOR_BGR2RGB)
    imglist.append(tmp)
    outputlist.append('{}'.format('combine'))
plot_multiple(imglist, outputlist, max_columns= 3)
```