Deep Learning for Computer Vision NTU, Fall 2021

Homework #1

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Problem 1

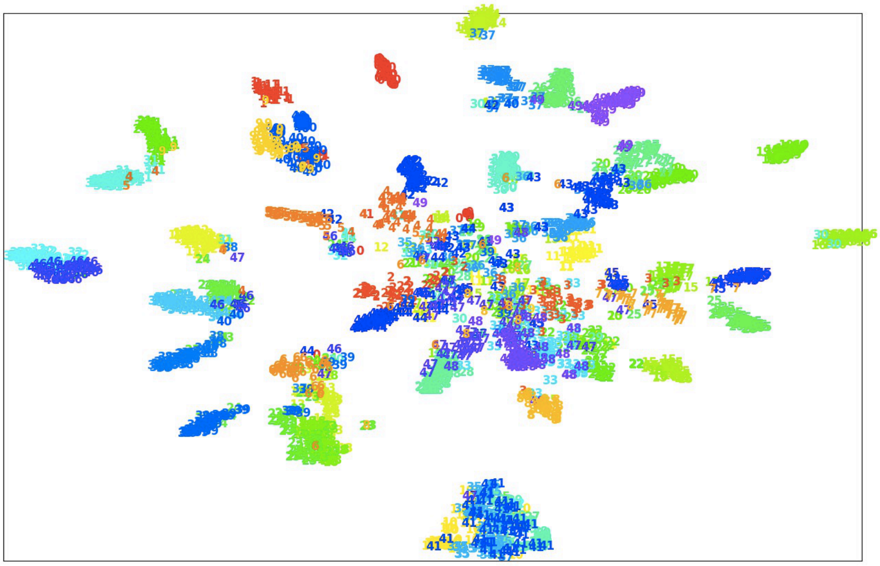
1. (2%) Print the network architecture of your model.

```
VGG16_model(
  (features): Sequential(
    (0): Conv2d(3, 64, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (1): ReLU(inplace=True)
    (2): Conv2d(64, 64, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (3): ReLU(inplace=True)
    (4): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1, ceil_mode=False)
    (5): Conv2d(64, 128, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (6): ReLU(inplace=True)
    (7): Conv2d(128, 128, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (8): ReLU(inplace=True)
    (9): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1, ceil_mode=False)
    (10): Conv2d(128, 256, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (11): ReLU(inplace=True)
    (12): Conv2d(256, 256, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (13): ReLU(inplace=True)
    (14): Conv2d(256, 256, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (15): ReLU(inplace=True)
    (16): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1, ceil_mode=False)
    (17): Conv2d(256, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (18): ReLU(inplace=True)
    (19): Conv2d(512, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (20): ReLU(inplace=True)
    (21): Conv2d(512, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (22): ReLU(inplace=True)
    (23): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1, ceil_mode=False)
    (24): Conv2d(512, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (25): ReLU(inplace=True)
    (26): Conv2d(512, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (27): ReLU(inplace=True)
    (28): Dropout(p=0.5, inplace=False)
    (29): Conv2d(512, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (30): ReLU(inplace=True)
    (31): Dropout(p=0.5, inplace=False)
    (32): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1, ceil_mode=False)
  )
  (avgpool): AdaptiveAvgPool2d(output_size=(7, 7))
  (classifier): Sequential(
    (0): Linear(in_features=25088, out_features=4096, bias=True)
  )
  (ReLU): ReLU(inplace=True)
  (Dropout): Dropout(p=0.5, inplace=False)
  (fc2): Linear(in_features=4096, out_features=50, bias=True)
)
```

2. (2%) Report accuracy of model on the validation set. (TA will reproduce your results, error **±0.5%**)

0.80735

3. (6%) Visualize the classification result on validation set by implementing t-SNE on **output features of the second last layer**. Briefly explain your result of the tSNE visualization.



由圖可見在倒數第二層的 output 已經有不錯的分群效果，大致同類別的距離較近，不同類別間距離較遠，但仍有部分類別區分結果較差，例如 47、48 類分別是海豹及老鼠，都有長尾巴及毛茸圓滾身形，因此較難區分。

Problem 2

1. (5%) Print the network architecture of your VGG16-FCN32s model.

```
FCN32(
  (pool2): Sequential(
    (0): Conv2d(3, 64, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (1): ReLU(inplace=True)
    (2): Conv2d(64, 64, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (3): ReLU(inplace=True)
    (4): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1, ceil_mode=False)
    (5): Conv2d(64, 128, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (6): ReLU(inplace=True)
    (7): Conv2d(128, 128, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (8): ReLU(inplace=True)
    (9): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1, ceil_mode=False)
  )
  (pool3): Sequential(
    (0): Conv2d(128, 256, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (1): ReLU(inplace=True)
    (2): Conv2d(256, 256, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (3): ReLU(inplace=True)
    (4): Conv2d(256, 256, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (5): ReLU(inplace=True)
    (6): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1, ceil_mode=False)
  )
  (pool4): Sequential(
    (0): Conv2d(256, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (1): ReLU(inplace=True)
    (2): Conv2d(512, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (3): ReLU(inplace=True)
    (4): Conv2d(512, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (5): ReLU(inplace=True)
    (6): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1, ceil_mode=False)
  )
```

```
  (pool5): Sequential(
    (0): Conv2d(512, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (1): ReLU(inplace=True)
    (2): Conv2d(512, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (3): ReLU(inplace=True)
    (4): Conv2d(512, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (5): ReLU(inplace=True)
    (6): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1, ceil_mode=False)
  )
  (pool5_score): Sequential(
    (0): Conv2d(512, 4096, kernel_size=(7, 7), stride=(1, 1), padding=(3, 3))
    (1): ReLU(inplace=True)
    (2): Dropout(p=0.5, inplace=False)
    (3): Conv2d(4096, 4096, kernel_size=(2, 2), stride=(1, 1))
    (4): ReLU(inplace=True)
    (5): Dropout(p=0.5, inplace=False)
    (6): Conv2d(4096, 7, kernel_size=(1, 1), stride=(1, 1))
  )
  (pool5_up): ConvTranspose2d(7, 7, kernel_size=(64, 64), stride=(32, 32))
)
```

2. (5%) Implement an improved model which performs better than your baseline model. Print the network architecture of this model.

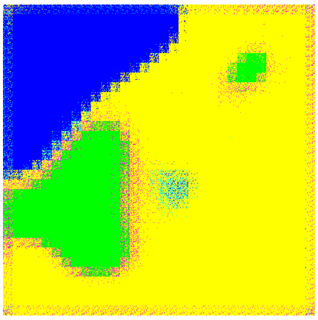
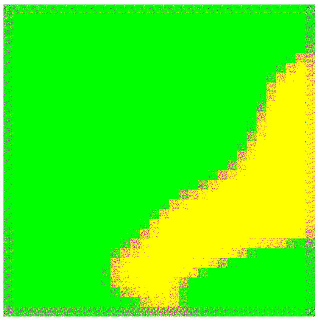
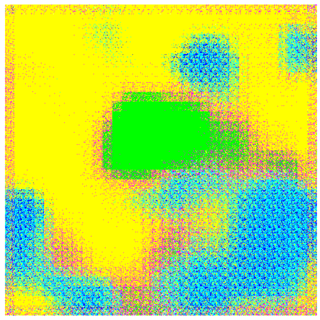
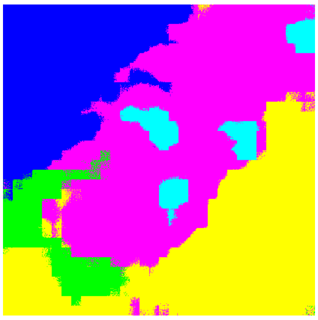
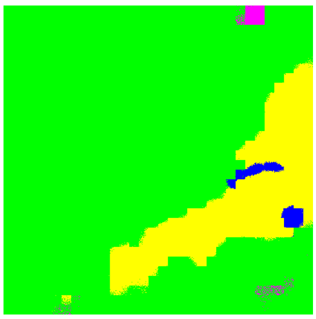
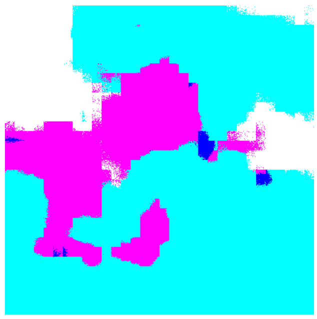
```
FCN16(
  (pool2): Sequential(
    (0): Conv2d(3, 64, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (1): ReLU(inplace=True)
    (2): Conv2d(64, 64, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (3): ReLU(inplace=True)
    (4): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1, ceil_mode=False)
    (5): Conv2d(64, 128, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (6): ReLU(inplace=True)
    (7): Conv2d(128, 128, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (8): ReLU(inplace=True)
    (9): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1, ceil_mode=False)
  )
  (pool3): Sequential(
    (0): Conv2d(128, 256, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (1): ReLU(inplace=True)
    (2): Conv2d(256, 256, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (3): ReLU(inplace=True)
    (4): Conv2d(256, 256, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (5): ReLU(inplace=True)
    (6): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1, ceil_mode=False)
  )
  (pool4): Sequential(
    (0): Conv2d(256, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (1): ReLU(inplace=True)
    (2): Conv2d(512, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (3): ReLU(inplace=True)
    (4): Conv2d(512, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (5): ReLU(inplace=True)
    (6): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1, ceil_mode=False)
  )
```

```
  (pool5): Sequential(
    (0): Conv2d(512, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (1): ReLU(inplace=True)
    (2): Conv2d(512, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (3): ReLU(inplace=True)
    (4): Conv2d(512, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (5): ReLU(inplace=True)
    (6): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1, ceil_mode=False)
  )
  (pool5_score): Sequential(
    (0): Conv2d(512, 4096, kernel_size=(7, 7), stride=(1, 1), padding=(3, 3))
    (1): ReLU(inplace=True)
    (2): Dropout(p=0.5, inplace=False)
    (3): Conv2d(4096, 4096, kernel_size=(2, 2), stride=(1, 1))
    (4): ReLU(inplace=True)
    (5): Dropout(p=0.5, inplace=False)
    (6): Conv2d(4096, 7, kernel_size=(1, 1), stride=(1, 1))
  )
  (pool5_up): ConvTranspose2d(7, 7, kernel_size=(4, 4), stride=(2, 2))
  (pool4_score): Sequential(
    (0): Conv2d(512, 2048, kernel_size=(7, 7), stride=(1, 1), padding=(3, 3))
    (1): ReLU(inplace=True)
    (2): Dropout(p=0.5, inplace=False)
    (3): Conv2d(2048, 7, kernel_size=(1, 1), stride=(1, 1))
  )
  (pool4_up): Sequential(
    (0): Conv2d(7, 7, kernel_size=(2, 2), stride=(1, 1))
    (1): ConvTranspose2d(7, 7, kernel_size=(32, 32), stride=(16, 16))
  )
)
```

3. (5%) Report mIoU of the improved model on the validation set. (TA will reproduce your results, error **±0.5%**)

0.71702

4. (5%) Show the predicted segmentation mask of “validation/0010_sat.jpg”, “validation/0097_sat.jpg”, “validation/0107_sat.jpg” during the early, middle, and the final stage during the training process of this improved model.

	0010_mask	0097_mask	0107_mask
Epoch1			
Epoch20			
Epoch40