IE 643
Deep Learning – Theory and Practice
Challenge Dataset for Image Segmentation

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INTRODUCTION
The dataset is a camouflage dataset, and the objective is to design an architecture for achieving the best possible results. The current state-of-the-art network is the **U-Net architecture**.

DATA PREPROCESSING –
1. **Resizing** (torchvision.transforms.Resize((128,128)):
   Resized all the images to 128 x 128 images. Reason: All the images in the dataset were of different sizes.

2. **Tensor conversion** (torchvision.transforms.ToTensor():
   All the images were converted to PyTorch Tensors, for using the GPU

3. **Grayscaling Masks** (torchvision.transforms.Grayscale():
   There was 1 mask which was an RGB image, hance applied grayscaling on all masks

4. **Normalization** (torchvision.transforms.Normalize()):
   Normalized the data to mean of 0 and variance of 1 assuming the mean and variance to be 0.5 for both

5. **Horizontal Flipping** (torchvision.transforms.RandomHorizontalFlip()):
   Appended horizontally flipped images of the train dataset to itself, to increase data. Set probability **p** parameter to **1** for the same

LOSS FUNCTION – **Binary Cross Entropy** (torch.nn.BCELoss())
(Did not use Dice loss, since it wasn't converging for the given camouflage dataset)

Learning Rate scheduler (LR scheduler) – **Step LR** with **gamma** = 0.5, and **step size** = 1

HISTORY OF TRIALS

1. **Pure U-Net** (Without Extra Horizontally Flipped Data)
    a. **Image Size:** 200 x 200
    b. **Batch Size:** 64
    c. **Epochs:** 25
    d. **Optimizer:** Adam
    e. **Trainable Parameters:** 21,315,347
    f. **Train Time:** 43m 20s
    g. Validation set
        i. **Jaccard Index** =
        ii. **Dice Score** =

2. **Longer U-Net** (Without Extra Horizontally Flipped Data)
    a. **Image Size:** 200 x 200
    b. **Batch Size:** 64
    c. **Epochs:** 30
    d. **Optimizer:** Adam
    e. **Trainable Parameters:** 26,037,011
    f. **Train Time:** 66m 58s
    g. Validation set
        i. **Jaccard Index** =
        ii. **Dice Score** =

3. **U-Net** (**With** Extra Horizontally Flipped Data)
    a. **Image Size:** 128 x 128 (To increase speed of training)
    b. **Batch Size:** 64
    c. **Epochs:** 25
    d. **Optimizer:** Adam
    e. **Trainable Parameters:** 26,037,011
    f. **Train Time:** 38m 6s
    g. Validation set
        i. **Jaccard Index** = 0.2078
        ii. **Dice Score** = 0.3441

4. **Dense Inception U-Net** (**With** Extra Horizontally Flipped Data)
    a. **Image Size:** 128 x 128
    b. **Batch Size:** 64
    c. **Epochs:** 20
    d. **Optimizer:** Adam
    e. **Trainable Parameters:** 39,507,523
    f. **Train Time:** 51m 32s
    g. Validation set
        i. **Jaccard Index** = 0.3248
        ii. **Dice Score** = 0.4903

5. **Increased Dense Inception U-Net** (**With** Extra Horizontally Flipped Data)
    a. **Image Size:** 128 x 128

b. **Batch Size:** 16
c. **Epochs:** 10
d. **Optimizer:** Adam
e. **Trainable Parameters:** 90,260,995
f. **Train Time:** 73m 28s
g. Validation set
    i. **Jaccard Index** = 0.3108
    ii. **Dice Score** = 0.4742

6. **Increased Dense Inception U-Net** (**With** Extra Horizontally Flipped Data)
    a. **Image Size:** 128 x 128
    b. **Batch Size:** 16
    c. **Epochs:** 10
    d. **Optimizer:** SGD (Changed)
    e. **Trainable Parameters:** 363,437,059
    f. **Train Time:** 110m 22s
    g. **Threshold:** 0.39
    h. Train set
        i. **Jaccard Index** = 0.6416
        ii. **Dice Score** = 0.7817
    i. Validation set
        i. **Jaccard Index** = 0.3661
        ii. **Dice Score** = 0.5360

7. **DeepLab V3** (**With** Extra Horizontally Flipped Data)
    a. **Image Size:** 128 x 128
    b. **Batch Size:** 16
    c. **Epochs:** 5
    d. **Optimizer:** SGD
    e. **Trainable Parameters:** 60,991,062
    f. **Train Time:** 3m 22s
    g. **Threshold:** 0.5
    h. Train set
        i. **Jaccard Index** = 0.7383
        ii. **Dice Score** = 0.8494
    i. Validation set
        i. **Jaccard Index** = 0.5232
        ii. **Dice Score** = 0.6870

8. DeepLab V3
    a. Changes –
        i. **With** Extra Horizontally Flipped Data
        ii. **Added** Sharpness to Flipped Data
    b. **Batch Size:** 16
    c. **Epochs:** 5
    d. **Optimizer:** SGD
    e. **Trainable Parameters:** 60,991,062
    f. **Train Time:** 3m 4s

g. **Threshold:** 0.5
h. Comments: Did not perform as well

9. DeepLab V3
    a. Changes –
        i. **Loss** changed to **IoU Loss** from **BCE Loss**
    b. **Batch Size:** 16
    c. **Epochs:** 10
    d. **Optimizer:** SGD
    e. **Trainable Parameters:** 60,991,062
    f. **Train Time:** 7m 49s
    g. **Threshold:** 0.5
    h. Train set
        i. **Jaccard Index** = 0.7422
        ii. **Dice Score** = 0.8520
    i. Validation set
        i. **Jaccard Index** = 0.5451
        ii. **Dice Score** = 0.7056

10. DeepLab V3
    a. Changes –
        i. Added **IoU Loss** and **BCE Loss**
    b. **Batch Size:** 16
    c. **Epochs:** 10
    d. **Optimizer:** SGD
    e. **Trainable Parameters:** 60,991,062
    f. **Train Time:** 7m 49s
    g. **Threshold:** 0.5
    h. Train set
        i. **Jaccard Index** = 0.7791
        ii. **Dice Score** = 0.8758
    i. Validation set
        i. **Jaccard Index** = 0.5504
        ii. **Dice Score** = 0.7099

11. DeepLab V3
    a. Changes –
        i. Added Vertically Flipped images to train dataset
    b. **Batch Size:** 16
    c. **Epochs:** 10
    d. **Optimizer:** SGD
    e. **Trainable Parameters:** 60,991,062
    f. **Train Time:** 11m 43s
    g. **Threshold:** 0.49
    h. Train set
        i. **Jaccard Index** = 0.7415

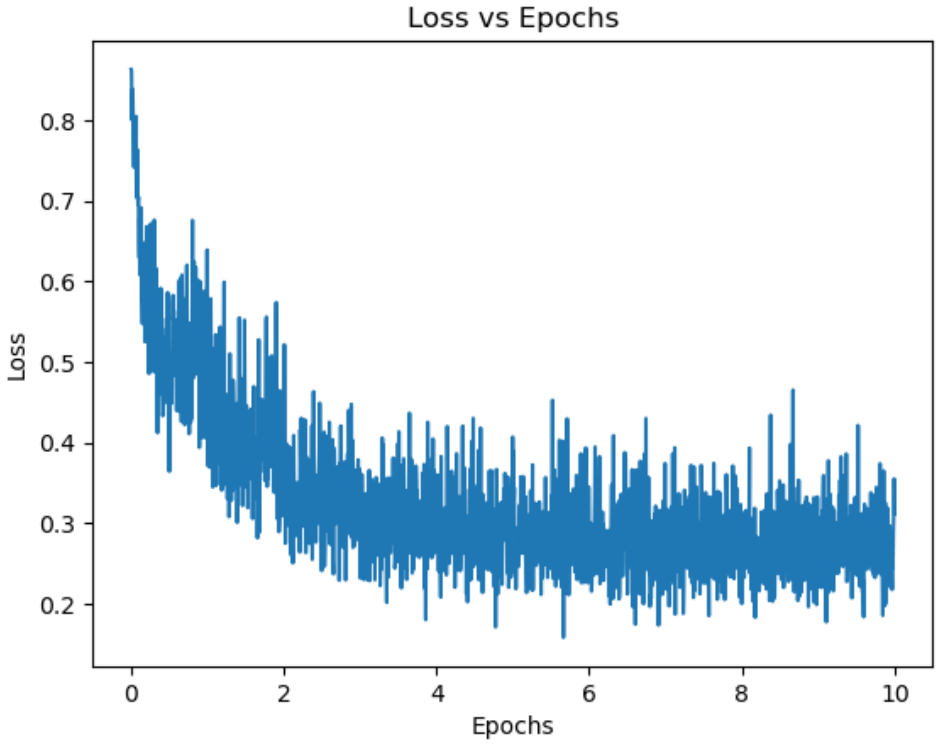
ii. **Dice Score** = 0.8515

i. Validation set
   i. **Jaccard Index** = 0.5643
   ii. **Dice Score** = 0.7215

FINAL MODEL – **DEEP LAB V3 Transfer Learnt Model**

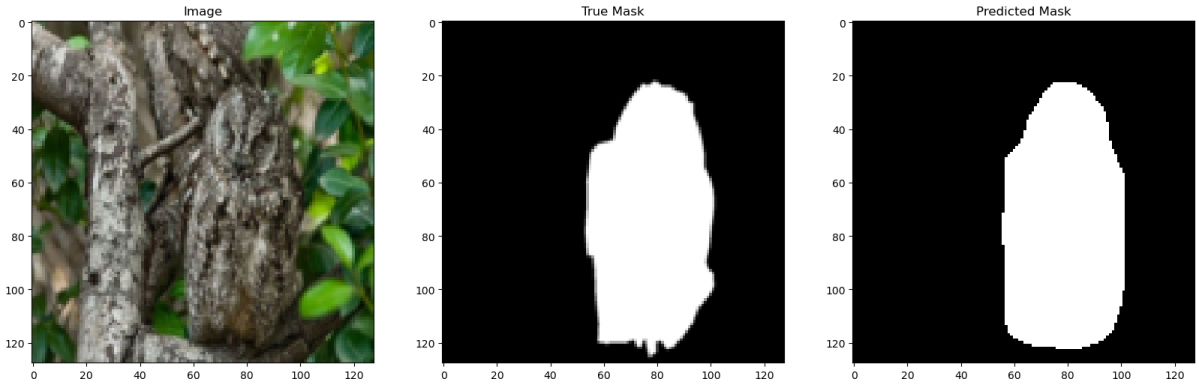
a. **Dataset:** Added horizontally and vertically flipped images to the dataset
b. **Image Size:** 128 x 128
c. **Batch Size:** 16
d. **GPU:** MPS (Metal Performance Shaders)
e. **Epochs:** 10
f. **Optimizer:** SGD
g. **Learning Rate =** 0.1
h. **LR Scheduler: Step LR** with gamma = 0.5 with step size = 1
i. **Trainable Parameters:** 60,991,062
j. **Train Time:** 11m 43s
k. Train dataset
   Jaccard Index = 0.7415
   Dice Score = 0.8515
l. Validation dataset
   Jaccard Index = 0.5643
   Dice Score = 0.7215

LOSS Function



RESULTS

1. Train Data example image



2. Validation Data example image