Update 1

In [1]:

```
from pathlib import Path
import re
import matplotlib.pyplot as plt
import torch
import torch.nn
import torchvision
from torch.utils.data import Dataset
import torch.nn as nn
import numpy as np
import warnings
warnings.filterwarnings("ignore")
from torchvision.transforms import ToPILImage
from IPython.display import HTML, display
```

In [6]:

```
# Creating a CustomDataset class which retrives the images and annotations.

class Custom_Dataset(Dataset):
    def __init__(self,path_of_image,path_of_maskedimage):
        super().__init__()
        images_path = Path(path_of_image)
        maskedimages_path = Path(path_of_maskedimage)
        self.images = [p for p in images_path.glob('*.jpg')]
        self.maskedimages = [p for p in maskedimages_path.glob('*.png')]
        self.transform1 = torchvision.transforms.Compose([torchvision.transforms.Re
                                                           torchvision.transforms.Nor
        self.transform2 = torchvision.transforms.Compose([torchvision.transforms.Re
                                                           torchvision.transforms.Nor

    def __len__(self):
        length = len(self.images)
        return length

    def __getitem__(self,index):
        img = torchvision.io.read_image(str(self.images[index]))
        masked_img = torchvision.io.read_image(str(self.maskedimages[index]))
        img = torch.tensor(img,dtype=torch.float)
        masked_img = torch.tensor(masked_img,dtype=torch.float)
        img = self.transform1(img)
        masked_img = self.transform2(masked_img)
        return img,masked_img
```

In [7]:

```
# Creating a tuple of Training, Validation and Testing Datasets.
d = (Custom_Dataset('/kaggle/input/dl-update1/Dataset_train_val_test/Images/train',
```

In [8]:

```
def print_with_font_size(text, font_size=5):
    display(HTML(f"<font size='{font_size}'>{text}</font>"))
```

In [ ]:

```
for i in range(0,3):
    dataset = d[i]
    train_dataloader = torch.utils.data.DataLoader(dataset,batch_size=8)
    if i == 0 :
        print_with_font_size("Images and Annotated Images of Training Images : ", f
    elif i == 1 :
        print_with_font_size("Images and Annotated Images of Validation Images : ",
    else :
        print_with_font_size("Images and Annotated Images of Testing Images : ", fo
    for batch in train_dataloader:
        imgs,masked_imgs = batch
        img_np = imgs[0].permute([1,2,0]).numpy()
        maskedimage_np = masked_imgs[0].permute([1,2,0]).numpy()
        fig, (ax1, ax2) = plt.subplots(1, 2, figsize=(10, 5))
        ax1.imshow(img_np)
        ax2.imshow(maskedimage_np)
        plt.show()
```

Update 2

Import Libraries

In [10]:

```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split
import torch
import torch.nn as nn
from torch.utils.data import Dataset, DataLoader
from torchvision import transforms as T
import torchvision
import torch.nn.functional as F
from torch.autograd import Variable
from PIL import Image
import cv2
import albumentations as A
import time
import os
from tqdm.notebook import tqdm


!pip install -q segmentation-models-pytorch
!pip install -q torchsummary

from torchsummary import summary
import segmentation_models_pytorch as smp
```

```
WARNING: Running pip as the 'root' user can result in broken permissions and confl
icting behaviour with the system package manager. It is recommended to use a virtu
al environment instead: https://pip.pypa.io/warnings/venv
WARNING: Running pip as the 'root' user can result in broken permissions and confl
icting behaviour with the system package manager. It is recommended to use a virtu
al environment instead: https://pip.pypa.io/warnings/venv
```

In [13]:

```
device = torch.device("cuda" if torch.cuda.is_available() else "cpu")
```

Preprocessing

In [14]:

```
IMAGE_PATH = '/kaggle/input/dl-dataset/image/'
MASK_PATH = '/kaggle/input/dl-dataset/labels/'
```

In [15]:

```
n_classes = 5

def create_df():
    name = []
    for dirname, _, filenames in os.walk(IMAGE_PATH):
        for filename in filenames:
            name.append(filename.split('.')[0])

    return pd.DataFrame({'id': name}, index = np.arange(0, len(name)))

df = create_df()
print('Total Images: ', len(df))
```

```
Total Images:  130
```

In [16]:

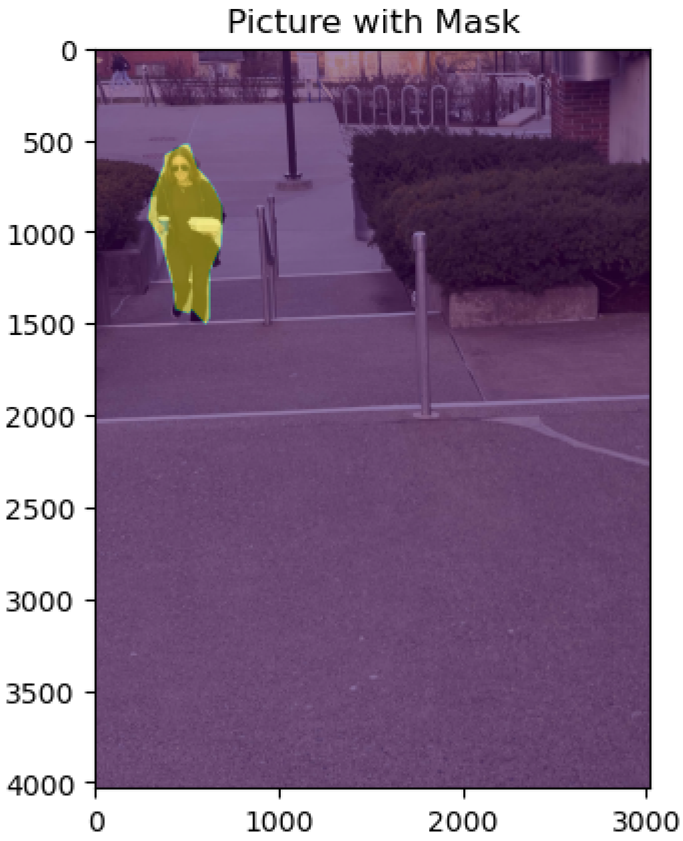
```
# data Split to Train, Validation and test
X_trainval, X_test = train_test_split(df['id'].values, test_size=0.1, random_state=
X_train, X_val = train_test_split(X_trainval, test_size=0.11, random_state=19)

print('Train Size   : ', len(X_train))
print('Val Size     : ', len(X_val))
print('Test Size    : ', len(X_test))
```

```
Train Size   :  104
Val Size     :  13
Test Size    :  13
```

In [18]:

```
img = Image.open(IMAGE_PATH + df['id'][79] + '.jpg')
mask = Image.open(MASK_PATH + df['id'][79] + '.png')
print('Image Size', np.asarray(img).shape)
print('Mask Size', np.asarray(mask).shape)

plt.imshow(img)
plt.imshow(mask, alpha=0.5)
plt.title('Picture with Mask')
plt.show()
```

```
Image Size (4032, 3024, 3)
Mask Size (4032, 3024)
```



Dataset

In [19]:

```python
class CustomDataset(Dataset):

    def __init__(self, img_path, mask_path, X, mean, std, transform=None, patch=Fal
        self.img_path = img_path
        self.mask_path = mask_path
        self.X = X
        self.transform = transform
        self.patches = patch
        self.mean = mean
        self.std = std

    def __len__(self):
        return len(self.X)

    def __getitem__(self, idx):
        img = cv2.imread(self.img_path + self.X[idx] + '.jpg')
        img = cv2.cvtColor(img, cv2.COLOR_BGR2RGB)
        mask = cv2.imread(self.mask_path + self.X[idx] + '.png', cv2.IMREAD_GRAYSCA

        if self.transform is not None:
            aug = self.transform(image=img, mask=mask)
            img = Image.fromarray(aug['image'])
            mask = aug['mask']

        if self.transform is None:
            img = Image.fromarray(img)

        t = T.Compose([T.ToTensor(), T.Normalize(self.mean, self.std)])
        img = t(img)
        mask = torch.from_numpy(mask).long()

        if self.patches:
            img, mask = self.tiles(img, mask)

        return img, mask

    def tiles(self, img, mask):

        img_patches = img.unfold(1, 512, 512).unfold(2, 768, 768)
        img_patches  = img_patches.contiguous().view(3,-1, 512, 768)
        img_patches = img_patches.permute(1,0,2,3)

        mask_patches = mask.unfold(0, 512, 512).unfold(1, 768, 768)
        mask_patches = mask_patches.contiguous().view(-1, 512, 768)

        return img_patches, mask_patches
```

In [20]:

```
mean=[0.485, 0.456, 0.406]
std=[0.229, 0.224, 0.225]

t_train = A.Compose([A.Resize(704, 1056, interpolation=cv2.INTER_NEAREST), A.Horizo
                     A.RandomBrightnessContrast((0,0.5),(0,0.5))])

t_val = A.Compose([A.Resize(704, 1056, interpolation=cv2.INTER_NEAREST), A.Horizont
                     A.RandomBrightnessContrast((0,0.5),(0,0.5))])

#datasets
train_set = CustomDataset(IMAGE_PATH, MASK_PATH, X_train, mean, std, t_train)
val_set = CustomDataset(IMAGE_PATH, MASK_PATH, X_val, mean, std, t_val)

#dataloader
batch_size= 8

train_loader = DataLoader(train_set, batch_size=batch_size, shuffle=True)
val_loader = DataLoader(val_set, batch_size=batch_size, shuffle=True)
```

Model

In [21]:

```
model = smp.Unet('mobilenet_v2', encoder_weights='imagenet', classes=5, activation=
```

```
Downloading: "https://download.pytorch.org/models/mobilenet_v2-b0353104.pth" to /r
oot/.cache/torch/hub/checkpoints/mobilenet_v2-b0353104.pth
  0%|          | 0.00/13.6M [00:00<?, ?B/s]
```

In [22]:

```
model
```

```
Out[22]: Unet(
           (encoder): MobileNetV2Encoder(
             (features): Sequential(
               (0): Conv2dNormActivation(
                 (0): Conv2d(3, 32, kernel_size=(3, 3), stride=(2, 2), padding=(1, 1), bias
         =False)
                 (1): BatchNorm2d(32, eps=1e-05, momentum=0.1, affine=True, track_running_s
         tats=True)
                 (2): ReLU6(inplace=True)
               )
               (1): InvertedResidual(
                 (conv): Sequential(
                   (0): Conv2dNormActivation(
                     (0): Conv2d(32, 32, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1),
         groups=32, bias=False)
                     (1): BatchNorm2d(32, eps=1e-05, momentum=0.1, affine=True, track_runni
         ng_stats=True)
                     (2): ReLU6(inplace=True)
                   )
                   (1): Conv2d(32, 16, kernel_size=(1, 1), stride=(1, 1), bias=False)
                   (2): BatchNorm2d(16, eps=1e-05, momentum=0.1, affine=True, track_running
         _stats=True)
                 )
               )
               (2): InvertedResidual(
                 (conv): Sequential(
                   (0): Conv2dNormActivation(
                     (0): Conv2d(16, 96, kernel_size=(1, 1), stride=(1, 1), bias=False)
                     (1): BatchNorm2d(96, eps=1e-05, momentum=0.1, affine=True, track_runni
         ng_stats=True)
                     (2): ReLU6(inplace=True)
                   )
                   (1): Conv2dNormActivation(
                     (0): Conv2d(96, 96, kernel_size=(3, 3), stride=(2, 2), padding=(1, 1),
         groups=96, bias=False)
                     (1): BatchNorm2d(96, eps=1e-05, momentum=0.1, affine=True, track_runni
         ng_stats=True)
                     (2): ReLU6(inplace=True)
                   )
                   (2): Conv2d(96, 24, kernel_size=(1, 1), stride=(1, 1), bias=False)
                   (3): BatchNorm2d(24, eps=1e-05, momentum=0.1, affine=True, track_running
         _stats=True)
                 )
               )
               (3): InvertedResidual(
                 (conv): Sequential(
                   (0): Conv2dNormActivation(
                     (0): Conv2d(24, 144, kernel_size=(1, 1), stride=(1, 1), bias=False)
                     (1): BatchNorm2d(144, eps=1e-05, momentum=0.1, affine=True, track_runn
         ing_stats=True)
                     (2): ReLU6(inplace=True)
                   )
                   (1): Conv2dNormActivation(
                     (0): Conv2d(144, 144, kernel_size=(3, 3), stride=(1, 1), padding=(1,
         1), groups=144, bias=False)
                     (1): BatchNorm2d(144, eps=1e-05, momentum=0.1, affine=True, track_runn
         ing_stats=True)
                     (2): ReLU6(inplace=True)
                   )
                   (2): Conv2d(144, 24, kernel_size=(1, 1), stride=(1, 1), bias=False)
                   (3): BatchNorm2d(24, eps=1e-05, momentum=0.1, affine=True, track_running
         _stats=True)
                 )
               )
               (4): InvertedResidual(
                 (conv): Sequential(
                   (0): Conv2dNormActivation(
                     (0): Conv2d(24, 144, kernel_size=(1, 1), stride=(1, 1), bias=False)
                     (1): BatchNorm2d(144, eps=1e-05, momentum=0.1, affine=True, track_runn
         ing_stats=True)
                     (2): ReLU6(inplace=True)
                   )
                   (1): Conv2dNormActivation(
                     (0): Conv2d(144, 144, kernel_size=(3, 3), stride=(2, 2), padding=(1,
         1), groups=144, bias=False)
                     (1): BatchNorm2d(144, eps=1e-05, momentum=0.1, affine=True, track_runn
         ing_stats=True)
                     (2): ReLU6(inplace=True)
                   )
                   (2): Conv2d(144, 32, kernel_size=(1, 1), stride=(1, 1), bias=False)
                   (3): BatchNorm2d(32, eps=1e-05, momentum=0.1, affine=True, track_running
         _stats=True)
                 )
               )
               (5): InvertedResidual(
                 (conv): Sequential(
                   (0): Conv2dNormActivation(
                     (0): Conv2d(32, 192, kernel_size=(1, 1), stride=(1, 1), bias=False)
                     (1): BatchNorm2d(192, eps=1e-05, momentum=0.1, affine=True, track_runn
         ing_stats=True)
                     (2): ReLU6(inplace=True)
                   )
                   (1): Conv2dNormActivation(
                     (0): Conv2d(192, 192, kernel_size=(3, 3), stride=(1, 1), padding=(1,
         1), groups=192, bias=False)
                     (1): BatchNorm2d(192, eps=1e-05, momentum=0.1, affine=True, track_runn
         ing_stats=True)
                     (2): ReLU6(inplace=True)
                   )
                   (2): Conv2d(192, 32, kernel_size=(1, 1), stride=(1, 1), bias=False)
                   (3): BatchNorm2d(32, eps=1e-05, momentum=0.1, affine=True, track_running
         _stats=True)
                 )
               )
               (6): InvertedResidual(
                 (conv): Sequential(
                   (0): Conv2dNormActivation(
                     (0): Conv2d(32, 192, kernel_size=(1, 1), stride=(1, 1), bias=False)
                     (1): BatchNorm2d(192, eps=1e-05, momentum=0.1, affine=True, track_runn
         ing_stats=True)
                     (2): ReLU6(inplace=True)
                   )
                   (1): Conv2dNormActivation(
                     (0): Conv2d(192, 192, kernel_size=(3, 3), stride=(1, 1), padding=(1,
         1), groups=192, bias=False)
                     (1): BatchNorm2d(192, eps=1e-05, momentum=0.1, affine=True, track_runn
         ing_stats=True)
                     (2): ReLU6(inplace=True)
                   )
                   (2): Conv2d(192, 32, kernel_size=(1, 1), stride=(1, 1), bias=False)
                   (3): BatchNorm2d(32, eps=1e-05, momentum=0.1, affine=True, track_running
         _stats=True)
                 )
               )
               (7): InvertedResidual(
                 (conv): Sequential(
                   (0): Conv2dNormActivation(
                     (0): Conv2d(32, 192, kernel_size=(1, 1), stride=(1, 1), bias=False)
                     (1): BatchNorm2d(192, eps=1e-05, momentum=0.1, affine=True, track_runn
         ing_stats=True)
                     (2): ReLU6(inplace=True)
                   )
                   (1): Conv2dNormActivation(
                     (0): Conv2d(192, 192, kernel_size=(3, 3), stride=(2, 2), padding=(1,
         1), groups=192, bias=False)
                     (1): BatchNorm2d(192, eps=1e-05, momentum=0.1, affine=True, track_runn
         ing_stats=True)
                     (2): ReLU6(inplace=True)
                   )
                   (2): Conv2d(192, 64, kernel_size=(1, 1), stride=(1, 1), bias=False)
                   (3): BatchNorm2d(64, eps=1e-05, momentum=0.1, affine=True, track_running
         _stats=True)
                 )
               )
               (8): InvertedResidual(
                 (conv): Sequential(
                   (0): Conv2dNormActivation(
                     (0): Conv2d(64, 384, kernel_size=(1, 1), stride=(1, 1), bias=False)
                     (1): BatchNorm2d(384, eps=1e-05, momentum=0.1, affine=True, track_runn
         ing_stats=True)
                     (2): ReLU6(inplace=True)
                   )
                   (1): Conv2dNormActivation(
                     (0): Conv2d(384, 384, kernel_size=(3, 3), stride=(1, 1), padding=(1,
         1), groups=384, bias=False)
                     (1): BatchNorm2d(384, eps=1e-05, momentum=0.1, affine=True, track_runn
         ing_stats=True)
                     (2): ReLU6(inplace=True)
                   )
                   (2): Conv2d(384, 64, kernel_size=(1, 1), stride=(1, 1), bias=False)
                   (3): BatchNorm2d(64, eps=1e-05, momentum=0.1, affine=True, track_running
         _stats=True)
                 )
               )
               (9): InvertedResidual(
                 (conv): Sequential(
                   (0): Conv2dNormActivation(
                     (0): Conv2d(64, 384, kernel_size=(1, 1), stride=(1, 1), bias=False)
                     (1): BatchNorm2d(384, eps=1e-05, momentum=0.1, affine=True, track_runn
         ing_stats=True)
                     (2): ReLU6(inplace=True)
                   )
                   (1): Conv2dNormActivation(
                     (0): Conv2d(384, 384, kernel_size=(3, 3), stride=(1, 1), padding=(1,
         1), groups=384, bias=False)
                     (1): BatchNorm2d(384, eps=1e-05, momentum=0.1, affine=True, track_runn
         ing_stats=True)
                     (2): ReLU6(inplace=True)
                   )
                   (2): Conv2d(384, 64, kernel_size=(1, 1), stride=(1, 1), bias=False)
                   (3): BatchNorm2d(64, eps=1e-05, momentum=0.1, affine=True, track_running
         _stats=True)
                 )
               )
               (10): InvertedResidual(
                 (conv): Sequential(
                   (0): Conv2dNormActivation(
                     (0): Conv2d(64, 384, kernel_size=(1, 1), stride=(1, 1), bias=False)
                     (1): BatchNorm2d(384, eps=1e-05, momentum=0.1, affine=True, track_runn
         ing_stats=True)
                     (2): ReLU6(inplace=True)
                   )
                   (1): Conv2dNormActivation(
                     (0): Conv2d(384, 384, kernel_size=(3, 3), stride=(1, 1), padding=(1,
         1), groups=384, bias=False)
                     (1): BatchNorm2d(384, eps=1e-05, momentum=0.1, affine=True, track_runn
         ing_stats=True)
                     (2): ReLU6(inplace=True)
                   )
                   (2): Conv2d(384, 64, kernel_size=(1, 1), stride=(1, 1), bias=False)
                   (3): BatchNorm2d(64, eps=1e-05, momentum=0.1, affine=True, track_running
         _stats=True)
                 )
               )
               (11): InvertedResidual(
                 (conv): Sequential(
                   (0): Conv2dNormActivation(
                     (0): Conv2d(64, 384, kernel_size=(1, 1), stride=(1, 1), bias=False)
                     (1): BatchNorm2d(384, eps=1e-05, momentum=0.1, affine=True, track_runn
         ing_stats=True)
                     (2): ReLU6(inplace=True)
                   )
                   (1): Conv2dNormActivation(
                     (0): Conv2d(384, 384, kernel_size=(3, 3), stride=(1, 1), padding=(1,
         1), groups=384, bias=False)
                     (1): BatchNorm2d(384, eps=1e-05, momentum=0.1, affine=True, track_runn
         ing_stats=True)
                     (2): ReLU6(inplace=True)
                   )
                   (2): Conv2d(384, 96, kernel_size=(1, 1), stride=(1, 1), bias=False)
                   (3): BatchNorm2d(96, eps=1e-05, momentum=0.1, affine=True, track_running
         _stats=True)
                 )
               )
               (12): InvertedResidual(
                 (conv): Sequential(
                   (0): Conv2dNormActivation(
                     (0): Conv2d(96, 576, kernel_size=(1, 1), stride=(1, 1), bias=False)
                     (1): BatchNorm2d(576, eps=1e-05, momentum=0.1, affine=True, track_runn
         ing_stats=True)
                     (2): ReLU6(inplace=True)
                   )
                   (1): Conv2dNormActivation(
                     (0): Conv2d(576, 576, kernel_size=(3, 3), stride=(1, 1), padding=(1,
         1), groups=576, bias=False)
                     (1): BatchNorm2d(576, eps=1e-05, momentum=0.1, affine=True, track_runn
         ing_stats=True)
                     (2): ReLU6(inplace=True)
                   )
                   (2): Conv2d(576, 96, kernel_size=(1, 1), stride=(1, 1), bias=False)
                   (3): BatchNorm2d(96, eps=1e-05, momentum=0.1, affine=True, track_running
         _stats=True)
                 )
               )
               (13): InvertedResidual(
                 (conv): Sequential(
                   (0): Conv2dNormActivation(
                     (0): Conv2d(96, 576, kernel_size=(1, 1), stride=(1, 1), bias=False)
                     (1): BatchNorm2d(576, eps=1e-05, momentum=0.1, affine=True, track_runn
         ing_stats=True)
                     (2): ReLU6(inplace=True)
                   )
                   (1): Conv2dNormActivation(
                     (0): Conv2d(576, 576, kernel_size=(3, 3), stride=(1, 1), padding=(1,
         1), groups=576, bias=False)
                     (1): BatchNorm2d(576, eps=1e-05, momentum=0.1, affine=True, track_runn
         ing_stats=True)
                     (2): ReLU6(inplace=True)
                   )
                   (2): Conv2d(576, 96, kernel_size=(1, 1), stride=(1, 1), bias=False)
                   (3): BatchNorm2d(96, eps=1e-05, momentum=0.1, affine=True, track_running
         _stats=True)
                 )
               )
               (14): InvertedResidual(
                 (conv): Sequential(
                   (0): Conv2dNormActivation(
                     (0): Conv2d(96, 576, kernel_size=(1, 1), stride=(1, 1), bias=False)
                     (1): BatchNorm2d(576, eps=1e-05, momentum=0.1, affine=True, track_runn
         ing_stats=True)
                     (2): ReLU6(inplace=True)
                   )
                   (1): Conv2dNormActivation(
                     (0): Conv2d(576, 576, kernel_size=(3, 3), stride=(2, 2), padding=(1,
         1), groups=576, bias=False)
                     (1): BatchNorm2d(576, eps=1e-05, momentum=0.1, affine=True, track_runn
         ing_stats=True)
                     (2): ReLU6(inplace=True)
                   )
                   (2): Conv2d(576, 160, kernel_size=(1, 1), stride=(1, 1), bias=False)
                   (3): BatchNorm2d(160, eps=1e-05, momentum=0.1, affine=True, track_runnin
         g_stats=True)
                 )
               )
               (15): InvertedResidual(
                 (conv): Sequential(
                   (0): Conv2dNormActivation(
                     (0): Conv2d(160, 960, kernel_size=(1, 1), stride=(1, 1), bias=False)
                     (1): BatchNorm2d(960, eps=1e-05, momentum=0.1, affine=True, track_runn
         ing_stats=True)
                     (2): ReLU6(inplace=True)
                   )
                   (1): Conv2dNormActivation(
                     (0): Conv2d(960, 960, kernel_size=(3, 3), stride=(1, 1), padding=(1,
         1), groups=960, bias=False)
                     (1): BatchNorm2d(960, eps=1e-05, momentum=0.1, affine=True, track_runn
         ing_stats=True)
                     (2): ReLU6(inplace=True)
                   )
                   (2): Conv2d(960, 160, kernel_size=(1, 1), stride=(1, 1), bias=False)
                   (3): BatchNorm2d(160, eps=1e-05, momentum=0.1, affine=True, track_runnin
         g_stats=True)
                 )
               )
               (16): InvertedResidual(
                 (conv): Sequential(
                   (0): Conv2dNormActivation(
                     (0): Conv2d(160, 960, kernel_size=(1, 1), stride=(1, 1), bias=False)
                     (1): BatchNorm2d(960, eps=1e-05, momentum=0.1, affine=True, track_runn
         ing_stats=True)
                     (2): ReLU6(inplace=True)
                   )
                   (1): Conv2dNormActivation(
                     (0): Conv2d(960, 960, kernel_size=(3, 3), stride=(1, 1), padding=(1,
         1), groups=960, bias=False)
                     (1): BatchNorm2d(960, eps=1e-05, momentum=0.1, affine=True, track_runn
         ing_stats=True)
                     (2): ReLU6(inplace=True)
                   )
                   (2): Conv2d(960, 160, kernel_size=(1, 1), stride=(1, 1), bias=False)
                   (3): BatchNorm2d(160, eps=1e-05, momentum=0.1, affine=True, track_runnin
         g_stats=True)
                 )
               )
               (17): InvertedResidual(
                 (conv): Sequential(
                   (0): Conv2dNormActivation(
                     (0): Conv2d(160, 960, kernel_size=(1, 1), stride=(1, 1), bias=False)
                     (1): BatchNorm2d(960, eps=1e-05, momentum=0.1, affine=True, track_runn
         ing_stats=True)
                     (2): ReLU6(inplace=True)
                   )
                   (1): Conv2dNormActivation(
                     (0): Conv2d(960, 960, kernel_size=(3, 3), stride=(1, 1), padding=(1,
         1), groups=960, bias=False)
                     (1): BatchNorm2d(960, eps=1e-05, momentum=0.1, affine=True, track_runn
         ing_stats=True)
                     (2): ReLU6(inplace=True)
                   )
                   (2): Conv2d(960, 320, kernel_size=(1, 1), stride=(1, 1), bias=False)
                   (3): BatchNorm2d(320, eps=1e-05, momentum=0.1, affine=True, track_runnin
         g_stats=True)
                 )
               )
               (18): Conv2dNormActivation(
                 (0): Conv2d(320, 1280, kernel_size=(1, 1), stride=(1, 1), bias=False)
                 (1): BatchNorm2d(1280, eps=1e-05, momentum=0.1, affine=True, track_running
         _stats=True)
                 (2): ReLU6(inplace=True)
               )
             )
           )
           (decoder): UnetDecoder(
             (center): Identity()
             (blocks): ModuleList(
               (0): DecoderBlock(
                 (conv1): Conv2dReLU(
                   (0): Conv2d(1376, 256, kernel_size=(3, 3), stride=(1, 1), padding=(1,
         1), bias=False)
                   (1): BatchNorm2d(256, eps=1e-05, momentum=0.1, affine=True, track_runnin
         g_stats=True)
                   (2): ReLU(inplace=True)
                 )
                 (attention1): Attention(
                   (attention): Identity()
                 )
                 (conv2): Conv2dReLU(
                   (0): Conv2d(256, 256, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1),
         bias=False)
                   (1): BatchNorm2d(256, eps=1e-05, momentum=0.1, affine=True, track_runnin
         g_stats=True)
                   (2): ReLU(inplace=True)
                 )
                 (attention2): Attention(
                   (attention): Identity()
                 )
               )
               (1): DecoderBlock(
                 (conv1): Conv2dReLU(
                   (0): Conv2d(288, 128, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1),
         bias=False)
                   (1): BatchNorm2d(128, eps=1e-05, momentum=0.1, affine=True, track_runnin
         g_stats=True)
                   (2): ReLU(inplace=True)
                 )
                 (attention1): Attention(
                   (attention): Identity()
                 )
                 (conv2): Conv2dReLU(
                   (0): Conv2d(128, 128, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1),
         bias=False)
                   (1): BatchNorm2d(128, eps=1e-05, momentum=0.1, affine=True, track_runnin
         g_stats=True)
                   (2): ReLU(inplace=True)
                 )
                 (attention2): Attention(
                   (attention): Identity()
                 )
               )
               (2): DecoderBlock(
                 (conv1): Conv2dReLU(
                   (0): Conv2d(152, 64, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1),
         bias=False)
                   (1): BatchNorm2d(64, eps=1e-05, momentum=0.1, affine=True, track_running
         _stats=True)
                   (2): ReLU(inplace=True)
                 )
                 (attention1): Attention(
                   (attention): Identity()
                 )
                 (conv2): Conv2dReLU(
                   (0): Conv2d(64, 64, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1), b
         ias=False)
                   (1): BatchNorm2d(64, eps=1e-05, momentum=0.1, affine=True, track_running
         _stats=True)
                   (2): ReLU(inplace=True)
                 )
                 (attention2): Attention(
                   (attention): Identity()
                 )
               )
               (3): DecoderBlock(
                 (conv1): Conv2dReLU(
                   (0): Conv2d(80, 32, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1), b
         ias=False)
                   (1): BatchNorm2d(32, eps=1e-05, momentum=0.1, affine=True, track_running
         _stats=True)
                   (2): ReLU(inplace=True)
                 )
                 (attention1): Attention(
                   (attention): Identity()
                 )
                 (conv2): Conv2dReLU(
                   (0): Conv2d(32, 32, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1), b
         ias=False)
                   (1): BatchNorm2d(32, eps=1e-05, momentum=0.1, affine=True, track_running
         _stats=True)
                   (2): ReLU(inplace=True)
                 )
                 (attention2): Attention(
                   (attention): Identity()
                 )
               )
               (4): DecoderBlock(
                 (conv1): Conv2dReLU(
                   (0): Conv2d(32, 16, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1), b
         ias=False)
                   (1): BatchNorm2d(16, eps=1e-05, momentum=0.1, affine=True, track_running
         _stats=True)
                   (2): ReLU(inplace=True)
                 )
                 (attention1): Attention(
                   (attention): Identity()
                 )
                 (conv2): Conv2dReLU(
                   (0): Conv2d(16, 16, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1), b
         ias=False)
                   (1): BatchNorm2d(16, eps=1e-05, momentum=0.1, affine=True, track_running
         _stats=True)
                   (2): ReLU(inplace=True)
                 )
                 (attention2): Attention(
                   (attention): Identity()
                 )
               )
             )
           )
           (segmentation_head): SegmentationHead(
             (0): Conv2d(16, 5, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
             (1): Identity()
             (2): Activation(
               (activation): Identity()
             )
           )
         )
```

Training

In [23]:

```
def pixel_accuracy(output, mask):
    with torch.no_grad():
        output = torch.argmax(F.softmax(output, dim=1), dim=1)
        correct = torch.eq(output, mask).int()
        accuracy = float(correct.sum()) / float(correct.numel())
    return accuracy
```

In [24]:

```
def mIoU(pred_mask, mask, smooth=1e-10, n_classes=23):
    with torch.no_grad():
        pred_mask = F.softmax(pred_mask, dim=1)
        pred_mask = torch.argmax(pred_mask, dim=1)
        pred_mask = pred_mask.contiguous().view(-1)
        mask = mask.contiguous().view(-1)

        iou_per_class = []
        for clas in range(0, n_classes): #loop per pixel class
            true_class = pred_mask == clas
            true_label = mask == clas

            if true_label.long().sum().item() == 0: #no exist label in this loop
                iou_per_class.append(np.nan)
            else:
                intersect = torch.logical_and(true_class, true_label).sum().float()
                union = torch.logical_or(true_class, true_label).sum().float().item
                iou = (intersect + smooth) / (union +smooth)
                iou_per_class.append(iou)
        return np.nanmean(iou_per_class)
```

In [25]:

```
def get_lr(optimizer):
    for param_group in optimizer.param_groups:
        return param_group['lr']

def fit(epochs, model, train_loader, val_loader, criterion, optimizer, scheduler, p
    torch.cuda.empty_cache()
    train_losses = []
    test_losses = []
    val_iou = []; val_acc = []
    train_iou = []; train_acc = []
    lrs = []
    min_loss = np.inf
    decrease = 1 ; not_improve=0

    model.to(device)
    fit_time = time.time()
    for e in range(epochs):
        since = time.time()
        running_loss = 0
        iou_score = 0
        accuracy = 0
        #training loop
        model.train()
        for i, data in enumerate(tqdm(train_loader)):
            #training phase
            image_tiles, mask_tiles = data
            if patch:
                bs, n_tiles, c, h, w = image_tiles.size()

                image_tiles = image_tiles.view(-1,c, h, w)
                mask_tiles = mask_tiles.view(-1, h, w)

            image = image_tiles.to(device); mask = mask_tiles.to(device);
            #forward
            output = model(image)
            loss = criterion(output, mask)
            #evaluation metrics
            iou_score += mIoU(output, mask)
            accuracy += pixel_accuracy(output, mask)
            #backward
            loss.backward()
            optimizer.step() #update weight
            optimizer.zero_grad() #reset gradient

            #step the learning rate
            lrs.append(get_lr(optimizer))
            scheduler.step()

            running_loss += loss.item()

        else:
            model.eval()
            test_loss = 0
            test_accuracy = 0
            val_iou_score = 0
            #validation loop
            with torch.no_grad():
                for i, data in enumerate(tqdm(val_loader)):
                    #reshape to 9 patches from single image, delete batch size
                    image_tiles, mask_tiles = data

                    if patch:
                        bs, n_tiles, c, h, w = image_tiles.size()

                        image_tiles = image_tiles.view(-1,c, h, w)
                        mask_tiles = mask_tiles.view(-1, h, w)

                    image = image_tiles.to(device); mask = mask_tiles.to(device);
                    output = model(image)
                    #evaluation metrics
                    val_iou_score +=  mIoU(output, mask)
                    test_accuracy += pixel_accuracy(output, mask)
                    #loss
                    loss = criterion(output, mask)
                    test_loss += loss.item()

            #calculatio mean for each batch
            train_losses.append(running_loss/len(train_loader))
            test_losses.append(test_loss/len(val_loader))


            if min_loss > (test_loss/len(val_loader)):
                print('Loss Decreasing.. {:.3f} >> {:.3f} '.format(min_loss, (test_
                min_loss = (test_loss/len(val_loader))
                decrease += 1
                if decrease % 5 == 0:
                    print('saving model...')
                    torch.save(model, 'Unet-Mobilenet_v2_mIoU-{:.3f}.pt'.format(val


            if (test_loss/len(val_loader)) > min_loss:
                not_improve += 1
                min_loss = (test_loss/len(val_loader))
                print(f'Loss Not Decrease for {not_improve} time')
                if not_improve == 7:
                    print('Loss not decrease for 7 times, Stop Training')
                    break




            #iou
            val_iou.append(val_iou_score/len(val_loader))
            train_iou.append(iou_score/len(train_loader))
            train_acc.append(accuracy/len(train_loader))
            val_acc.append(test_accuracy/ len(val_loader))
            print("Epoch:{}/{}..".format(e+1, epochs),
                  "Train Loss: {:.3f}..".format(running_loss/len(train_loader)),
                  "Val Loss: {:.3f}..".format(test_loss/len(val_loader)),
                  "Train mIoU:{:.3f}..".format(iou_score/len(train_loader)),
                  "Val mIoU: {:.3f}..".format(val_iou_score/len(val_loader)),
                  "Train Acc:{:.3f}..".format(accuracy/len(train_loader)),
                  "Val Acc:{:.3f}..".format(test_accuracy/len(val_loader)),
                  "Time: {:.2f}m".format((time.time()-since)/60))

    history = {'train_loss' : train_losses, 'val_loss': test_losses,
               'train_miou' :train_iou, 'val_miou':val_iou,
               'train_acc' :train_acc, 'val_acc':val_acc,
               'lrs': lrs}
    print('Total time: {:.2f} m' .format((time.time()- fit_time)/60))
    return history
```

In [26]:
```
max_lr = 1e-3
epoch = 16
weight_decay = 1e-4

criterion = nn.CrossEntropyLoss()
optimizer = torch.optim.AdamW(model.parameters(), lr=max_lr, weight_decay=weight_de
sched = torch.optim.lr_scheduler.OneCycleLR(optimizer, max_lr, epochs=epoch,
                                            steps_per_epoch=len(train_loader))

history = fit(epoch, model, train_loader, val_loader, criterion, optimizer, sched)
```

```
  0%|          | 0/13 [00:00<?, ?it/s]
  0%|          | 0/2 [00:00<?, ?it/s]
Loss Decreasing.. inf >> 6.582
Epoch:1/16.. Train Loss: 2.739.. Val Loss: 6.582.. Train mIoU:0.023.. Val mIoU: 0.
019.. Train Acc:0.047.. Val Acc:0.045.. Time: 0.59m
  0%|          | 0/13 [00:00<?, ?it/s]
  0%|          | 0/2 [00:00<?, ?it/s]
Loss Decreasing.. 6.582 >> 2.614
Epoch:2/16.. Train Loss: 1.994.. Val Loss: 2.614.. Train mIoU:0.048.. Val mIoU: 0.
093.. Train Acc:0.112.. Val Acc:0.241.. Time: 0.50m
  0%|          | 0/13 [00:00<?, ?it/s]
  0%|          | 0/2 [00:00<?, ?it/s]
Loss Decreasing.. 2.614 >> 1.831
Epoch:3/16.. Train Loss: 1.510.. Val Loss: 1.831.. Train mIoU:0.253.. Val mIoU: 0.
212.. Train Acc:0.505.. Val Acc:0.568.. Time: 0.50m
  0%|          | 0/13 [00:00<?, ?it/s]
  0%|          | 0/2 [00:00<?, ?it/s]
Loss Decreasing.. 1.831 >> 0.974
saving model...
Epoch:4/16.. Train Loss: 1.169.. Val Loss: 0.974.. Train mIoU:0.312.. Val mIoU: 0.
313.. Train Acc:0.723.. Val Acc:0.797.. Time: 0.49m
  0%|          | 0/13 [00:00<?, ?it/s]
  0%|          | 0/2 [00:00<?, ?it/s]
Loss Not Decrease for 1 time
Epoch:5/16.. Train Loss: 0.891.. Val Loss: 1.206.. Train mIoU:0.361.. Val mIoU: 0.
313.. Train Acc:0.803.. Val Acc:0.797.. Time: 0.50m
  0%|          | 0/13 [00:00<?, ?it/s]
  0%|          | 0/2 [00:00<?, ?it/s]
Loss Decreasing.. 1.206 >> 0.738
Epoch:6/16.. Train Loss: 0.726.. Val Loss: 0.738.. Train mIoU:0.362.. Val mIoU: 0.
390.. Train Acc:0.819.. Val Acc:0.840.. Time: 0.49m
```

```
  0%|          | 0/13 [00:00<?, ?it/s]
  0%|          | 0/2 [00:00<?, ?it/s]
Loss Decreasing.. 0.738 >> 0.518
Epoch:7/16.. Train Loss: 0.598.. Val Loss: 0.518.. Train mIoU:0.362.. Val mIoU: 0.
332.. Train Acc:0.825.. Val Acc:0.861.. Time: 0.49m
  0%|          | 0/13 [00:00<?, ?it/s]
  0%|          | 0/2 [00:00<?, ?it/s]
Loss Decreasing.. 0.518 >> 0.482
Epoch:8/16.. Train Loss: 0.533.. Val Loss: 0.482.. Train mIoU:0.393.. Val mIoU: 0.
367.. Train Acc:0.837.. Val Acc:0.879.. Time: 0.48m
  0%|          | 0/13 [00:00<?, ?it/s]
  0%|          | 0/2 [00:00<?, ?it/s]
Loss Decreasing.. 0.482 >> 0.458
Epoch:9/16.. Train Loss: 0.504.. Val Loss: 0.458.. Train mIoU:0.376.. Val mIoU: 0.
337.. Train Acc:0.845.. Val Acc:0.868.. Time: 0.49m
  0%|          | 0/13 [00:00<?, ?it/s]
  0%|          | 0/2 [00:00<?, ?it/s]
Loss Not Decrease for 2 time
Epoch:10/16.. Train Loss: 0.439.. Val Loss: 0.468.. Train mIoU:0.413.. Val mIoU:
0.343.. Train Acc:0.860.. Val Acc:0.867.. Time: 0.49m
  0%|          | 0/13 [00:00<?, ?it/s]
  0%|          | 0/2 [00:00<?, ?it/s]
Loss Not Decrease for 3 time
Epoch:11/16.. Train Loss: 0.421.. Val Loss: 0.472.. Train mIoU:0.420.. Val mIoU:
0.344.. Train Acc:0.854.. Val Acc:0.856.. Time: 0.48m
  0%|          | 0/13 [00:00<?, ?it/s]
  0%|          | 0/2 [00:00<?, ?it/s]
Loss Decreasing.. 0.472 >> 0.434
saving model...
Epoch:12/16.. Train Loss: 0.404.. Val Loss: 0.434.. Train mIoU:0.401.. Val mIoU:
0.364.. Train Acc:0.861.. Val Acc:0.876.. Time: 0.51m
  0%|          | 0/13 [00:00<?, ?it/s]
  0%|          | 0/2 [00:00<?, ?it/s]
Loss Decreasing.. 0.434 >> 0.388
Epoch:13/16.. Train Loss: 0.382.. Val Loss: 0.388.. Train mIoU:0.438.. Val mIoU:
0.364.. Train Acc:0.866.. Val Acc:0.885.. Time: 0.48m
  0%|          | 0/13 [00:00<?, ?it/s]
  0%|          | 0/2 [00:00<?, ?it/s]
Loss Not Decrease for 4 time
Epoch:14/16.. Train Loss: 0.359.. Val Loss: 0.416.. Train mIoU:0.434.. Val mIoU:
0.365.. Train Acc:0.879.. Val Acc:0.877.. Time: 0.49m
  0%|          | 0/13 [00:00<?, ?it/s]
  0%|          | 0/2 [00:00<?, ?it/s]
Loss Decreasing.. 0.416 >> 0.349
Epoch:15/16.. Train Loss: 0.360.. Val Loss: 0.349.. Train mIoU:0.464.. Val mIoU:
0.379.. Train Acc:0.878.. Val Acc:0.896.. Time: 0.49m
  0%|          | 0/13 [00:00<?, ?it/s]
  0%|          | 0/2 [00:00<?, ?it/s]
Loss Not Decrease for 5 time
Epoch:16/16.. Train Loss: 0.377.. Val Loss: 0.389.. Train mIoU:0.421.. Val mIoU:
0.375.. Train Acc:0.873.. Val Acc:0.886.. Time: 0.50m
Total time: 7.97 m
```

In [27]:

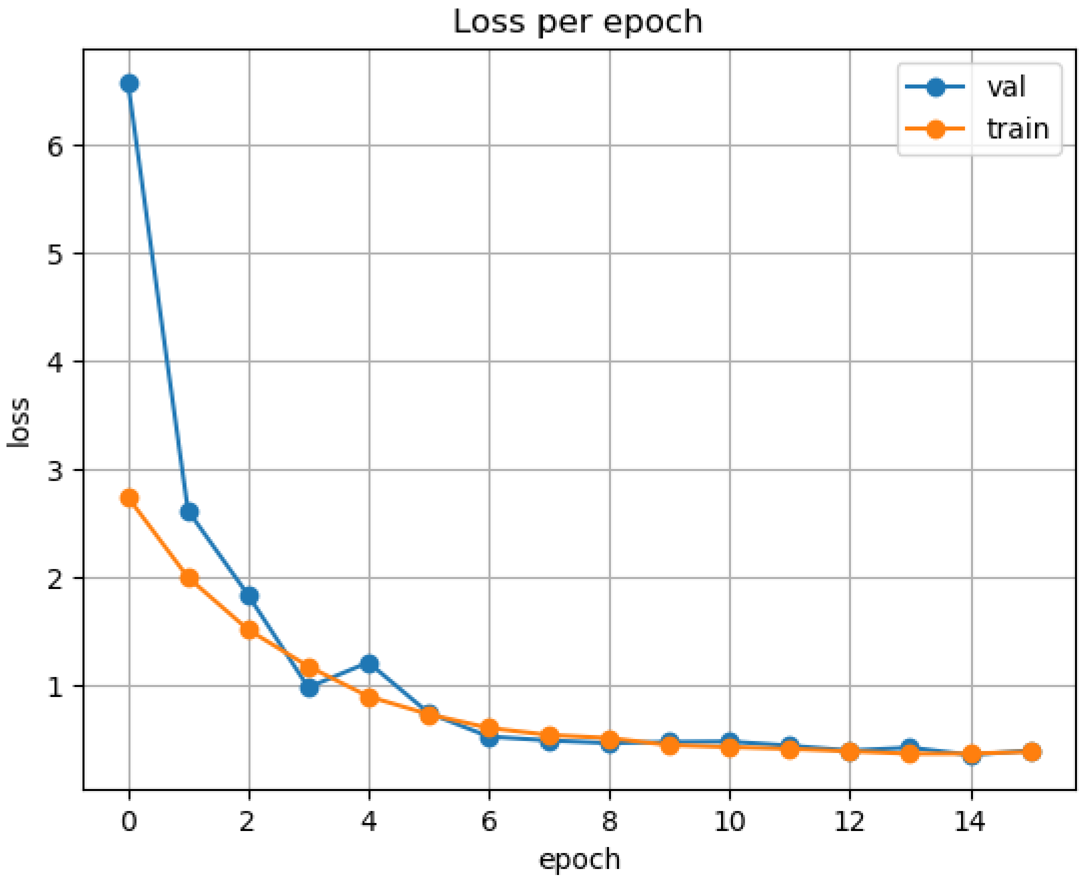
```
torch.save(model, 'model.pt')
```

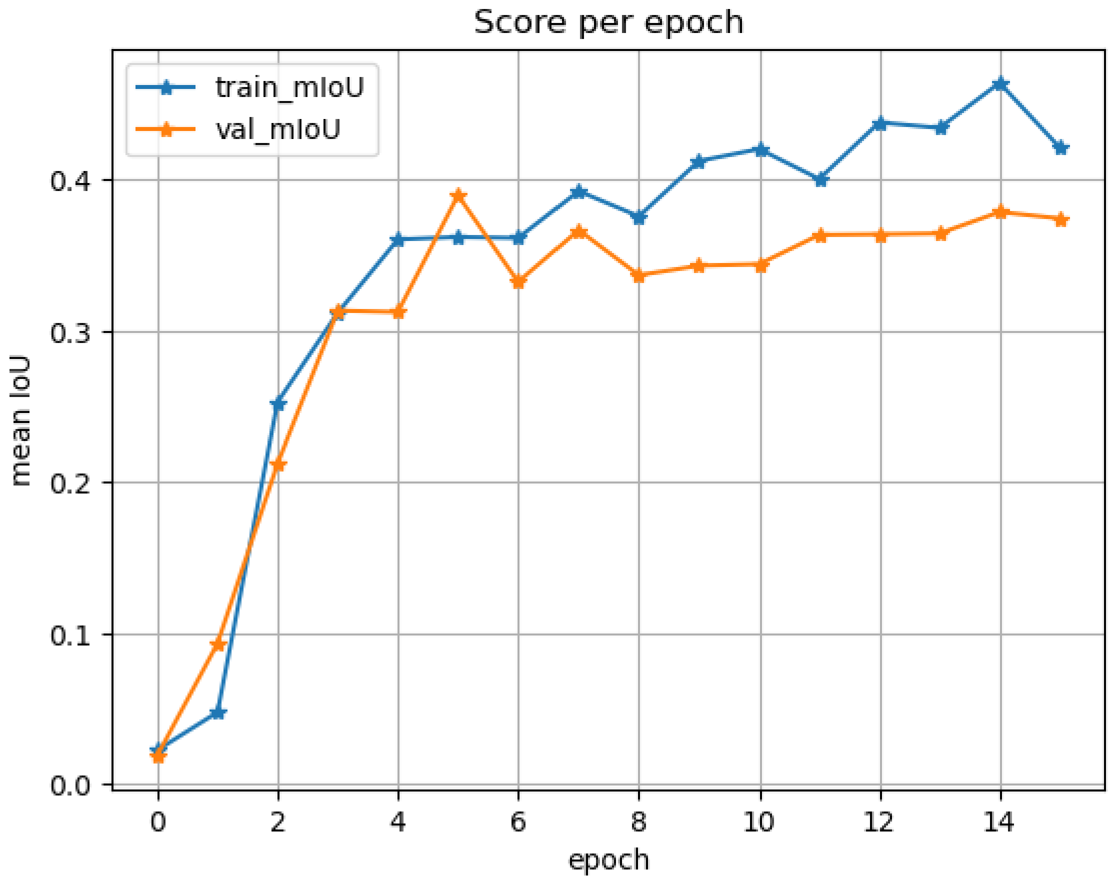
In [28]:

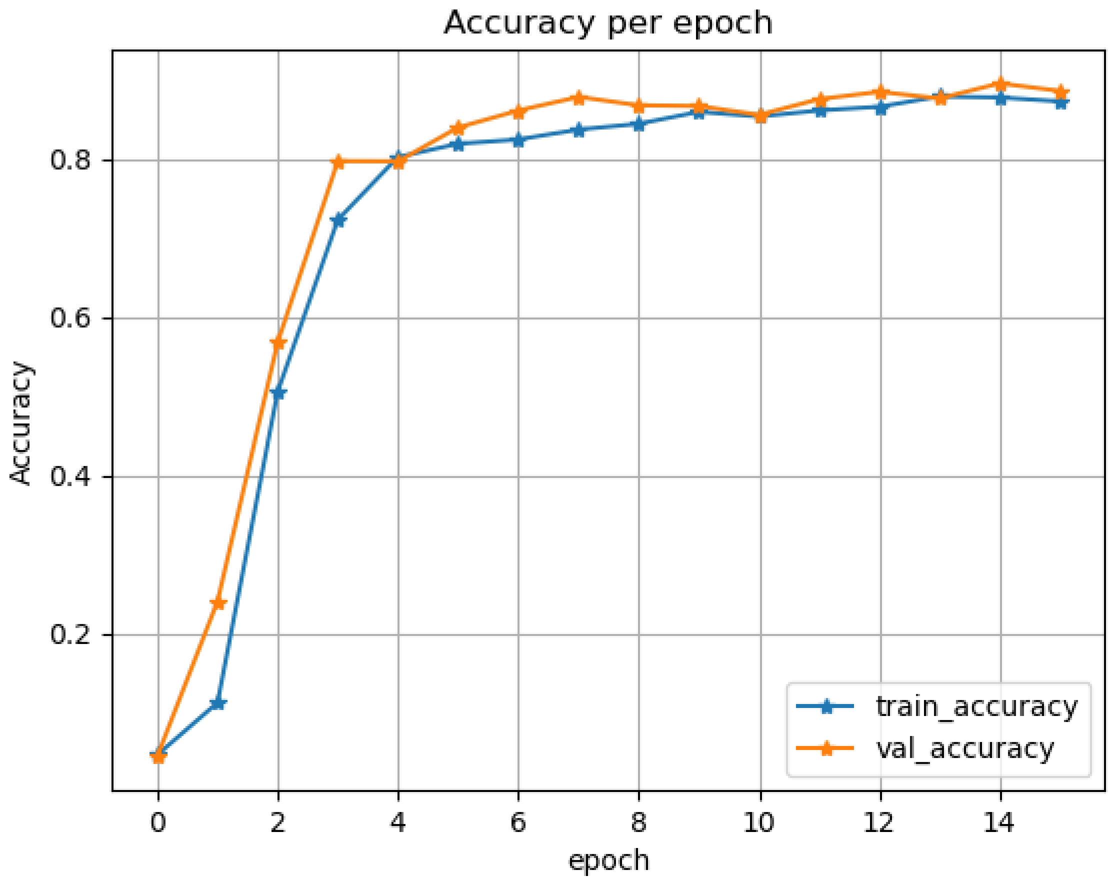
```
def plot_loss(history):
    plt.plot(history['val_loss'], label='val', marker='o')
    plt.plot( history['train_loss'], label='train', marker='o')
    plt.title('Loss per epoch'); plt.ylabel('loss');
    plt.xlabel('epoch')
    plt.legend(), plt.grid()
    plt.show()

def plot_score(history):
    plt.plot(history['train_miou'], label='train_mIoU', marker='*')
    plt.plot(history['val_miou'], label='val_mIoU',  marker='*')
    plt.title('Score per epoch'); plt.ylabel('mean IoU')
    plt.xlabel('epoch')
    plt.legend(), plt.grid()
    plt.show()

def plot_acc(history):
    plt.plot(history['train_acc'], label='train_accuracy', marker='*')
    plt.plot(history['val_acc'], label='val_accuracy',  marker='*')
    plt.title('Accuracy per epoch'); plt.ylabel('Accuracy')
    plt.xlabel('epoch')
    plt.legend(), plt.grid()
    plt.show()
```

In [29]:

```
plot_loss(history)
plot_score(history)
plot_acc(history)
```




Score per epoch
train_mIoU
val_mIoU
mean IoU
0.0
0.1
0.2
0.3
0.4
0
2
4
6
8
10
12
14
epoch


Accuracy per epoch
Accuracy
0.2
0.4
0.6
0.8
train_accuracy
val_accuracy
0
2
4
6
8
10
12
14
epoch

Evaluation

In [30]:

```
class CustomTestDataset(Dataset):

    def __init__(self, img_path, mask_path, X, transform=None):
        self.img_path = img_path
        self.mask_path = mask_path
        self.X = X
        self.transform = transform

    def __len__(self):
        return len(self.X)

    def __getitem__(self, idx):
        img = cv2.imread(self.img_path + self.X[idx] + '.jpg')
        img = cv2.cvtColor(img, cv2.COLOR_BGR2RGB)
        mask = cv2.imread(self.mask_path + self.X[idx] + '.png', cv2.IMREAD_GRAYSCA

        if self.transform is not None:
            aug = self.transform(image=img, mask=mask)
            img = Image.fromarray(aug['image'])
            mask = aug['mask']

        if self.transform is None:
            img = Image.fromarray(img)

        mask = torch.from_numpy(mask).long()

        return img, mask


t_test = A.Resize(768, 1152, interpolation=cv2.INTER_NEAREST)
test_set = CustomTestDataset(IMAGE_PATH, MASK_PATH, X_test, transform=t_test)
```

Result

In [31]:

```
def predict_image_mask_miou(model, image, mask, mean=[0.485, 0.456, 0.406], std=[0.
    model.eval()
    t = T.Compose([T.ToTensor(), T.Normalize(mean, std)])
    image = t(image)
    model.to(device); image=image.to(device)
    mask = mask.to(device)
    with torch.no_grad():

        image = image.unsqueeze(0)
        mask = mask.unsqueeze(0)

        output = model(image)
        score = mIoU(output, mask)
        masked = torch.argmax(output, dim=1)
        masked = masked.cpu().squeeze(0)
    return masked, score
```

In [32]:

```
def predict_image_mask_pixel(model, image, mask, mean=[0.485, 0.456, 0.406], std=[0
    model.eval()
    t = T.Compose([T.ToTensor(), T.Normalize(mean, std)])
    image = t(image)
    model.to(device); image=image.to(device)
    mask = mask.to(device)
    with torch.no_grad():

        image = image.unsqueeze(0)
        mask = mask.unsqueeze(0)

        output = model(image)
        acc = pixel_accuracy(output, mask)
        masked = torch.argmax(output, dim=1)
        masked = masked.cpu().squeeze(0)
    return masked, acc
```

In [33]:

```
image, mask = test_set[3]
pred_mask, score = predict_image_mask_miou(model, image, mask)
```

In [34]:

```
def miou_score(model, test_set):
    score_iou = []
    for i in tqdm(range(len(test_set))):
        img, mask = test_set[i]
        pred_mask, score = predict_image_mask_miou(model, img, mask)
        score_iou.append(score)
    return score_iou
```

In [35]:

```
Mean_IoU = miou_score(model, test_set)
```

```
  0%|          | 0/13 [00:00<?, ?it/s]
```

In [37]:

```
def pixel_acc(model, test_set):
    accuracy = []
    for i in tqdm(range(len(test_set))):
        img, mask = test_set[i]
        pred_mask, acc = predict_image_mask_pixel(model, img, mask)
        accuracy.append(acc)
    return accuracy
```

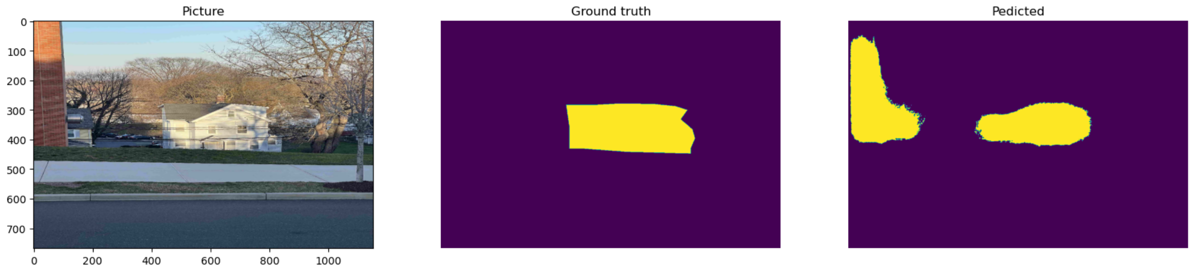
In [38]:

```
pixel_accuracy = pixel_acc(model, test_set)
```

```
  0%|          | 0/13 [00:00<?, ?it/s]
```

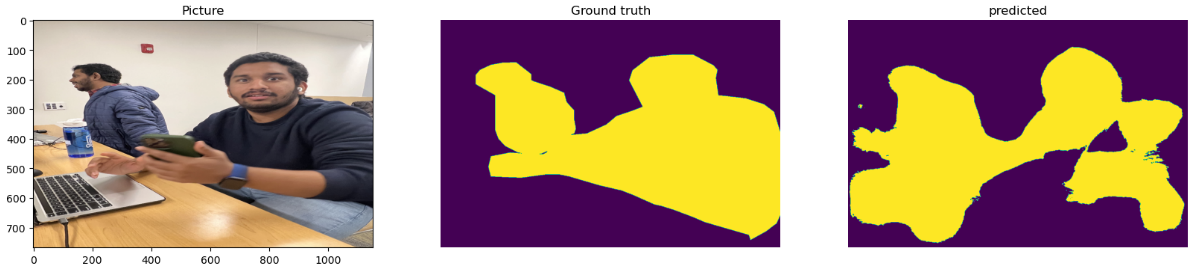
In [39]:

```
fig, (ax1, ax2, ax3) = plt.subplots(1,3, figsize=(20,10))
ax1.imshow(image)
ax1.set_title('Picture');

ax2.imshow(mask)
ax2.set_title('Ground truth')
ax2.set_axis_off()

ax3.imshow(pred_mask)
ax3.set_title('Pedicted')
ax3.set_axis_off()
```



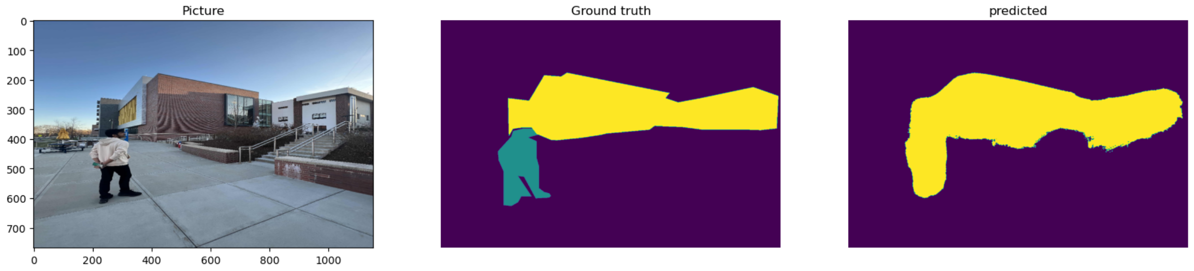
In [40]:

```
image2, mask2 = test_set[8]
pred_mask2, score2 = predict_image_mask_miou(model, image2, mask2)

fig, (ax1, ax2, ax3) = plt.subplots(1,3, figsize=(20,10))
ax1.imshow(image2)
ax1.set_title('Picture');

ax2.imshow(mask2)
ax2.set_title('Ground truth')
ax2.set_axis_off()

ax3.imshow(pred_mask2)
ax3.set_title('predicted')
ax3.set_axis_off()
```



In [41]:

```
image3, mask3 = test_set[11]
pred_mask3, score3 = predict_image_mask_miou(model, image3, mask3)

fig, (ax1, ax2, ax3) = plt.subplots(1,3, figsize=(20,10))
ax1.imshow(image3)
ax1.set_title('Picture');

ax2.imshow(mask3)
ax2.set_title('Ground truth')
ax2.set_axis_off()

ax3.imshow(pred_mask3)
ax3.set_title('predicted')
ax3.set_axis_off()
```



```
In [42]: print('Test Data mIoU', np.mean(Mean_IoU))
```

```
Test Data mIoU 0.6181245640293062
```

```
In [43]: print('Test data pixel Accuracy', np.mean(pixel_accuracy))
```

```
Test data pixel Accuracy 0.8790450136885684
```

```
In [ ]:
```