```
# IMPORTANT: RUN THIS CELL IN ORDER TO IMPORT YOUR KAGGLE DATA SOURCES,
# THEN FEEL FREE TO DELETE THIS CELL.
# NOTE: THIS NOTEBOOK ENVIRONMENT DIFFERS FROM KAGGLE'S PYTHON
# ENVIRONMENT SO THERE MAY BE MISSING LIBRARIES USED BY YOUR
# NOTEBOOK.
import kagglehub
bulentsiyah_semantic_drone_dataset_path = kagglehub.dataset_download('bulentsiyah/semantic-drone-dataset')

print('Data source import complete.')
```

About This Kernel

- What is the purpose of the study?

I am working on Deep Learning and Computer Vision in Flying Automobile Project. The project I am working on are Semantic segmentation (Aerial images) during the flight of the vehicle to find suitable areas where the vehicle can land. To make volumetric control of the vehicle to these areas.

With this kernel, I have completed working on the **Semantic segmentation**

Content

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1.What is semantic segmentation

Source: https://divamgupta.com/image-segmentation/2019/06/06/deep-learning-semantic-segmentation-keras.html

Semantic image segmentation is the task of classifying each pixel in an image from a predefined set of classes. In the following example, different entities are classified.

In the above example, the pixels belonging to the bed are classified in the class “bed”, the pixels corresponding to the walls are labeled as “wall”, etc.

In particular, our goal is to take an image of size W x H x 3 and generate a W x H matrix containing the predicted class ID’s corresponding to all the pixels.

segmented

1: Person
2: Purse
3: Plants/Grass
4: Sidewalk
5: Building/Structures

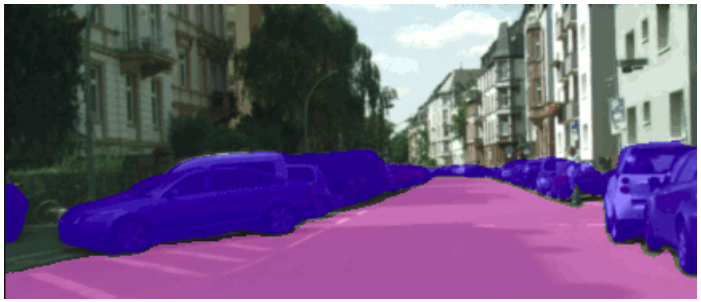
3	3	3	3	3	3	3	3	3	3	3	3	5	5	5	5	5	5
3	3	3	3	3	3	3	3	3	3	3	3	5	5	5	5	5	5
3	3	3	3	3	3	1	1	3	3	3	3	5	5	5	5	5	5
3	3	3	3	3	1	1	1	1	3	3	3	5	5	5	5	5	5
3	3	3	3	3	3	1	1	3	3	3	5	5	5	5	5	5	5
5	5	3	3	3	3	1	1	3	3	5	5	5	5	5	5	5	5
4	4	3	4	1	1	1	1	1	1	4	4	4	5	5	5	5	5
4	4	3	4	1	1	1	1	1	1	4	4	4	4	4	5	5	5
4	4	4	1	1	1	1	1	1	1	1	4	4	4	4	4	4	4
3	3	3	1	1	1	1	1	1	1	1	4	4	4	4	4	4	4
3	3	3	1	2	2	1	1	1	1	1	4	4	4	4	4	4	4
3	3	3	1	2	2	1	1	1	1	1	4	4	4	4	4	4	4

Input

Semantic Labels

Usually, in an image with various entities, we want to know which pixel belongs to which entity, For example in an outdoor image, we can segment the sky, ground, trees, people, etc.

Semantic segmentation is different from object detection as it does not predict any bounding boxes around the objects. We do not distinguish between different instances of the same object. For example, there could be multiple cars in the scene and all of them would have the same label.



In order to perform semantic segmentation, a higher level understanding of the image is required. The algorithm should figure out the objects present and also the pixels which correspond to the object. Semantic segmentation is one of the essential tasks for complete scene understanding.

Dataset

The first step in training our segmentation model is to prepare the dataset. We would need the input RGB images and the corresponding segmentation images. If you want to make your own dataset, a tool like labelme or GIMP can be used to manually generate the ground truth segmentation masks.

Assign each class a unique ID. In the segmentation images, the pixel value should denote the class ID of the corresponding pixel. This is a common format used by most of the datasets and keras_segmentation. For the segmentation maps, do not use the jpg format as jpg is lossy and the pixel values might change. Use bmp or png format instead. And of course, the size of the input image and the segmentation image should be the same.

In the following example, pixel (0,0) is labeled as class 2, pixel (3,4) is labeled as class 1 and rest of the pixels are labeled as class 0.

```
import cv2
import numpy as np

ann_img = np.zeros((30,30,3)).astype('uint8')
ann_img[ 3 , 4 ] = 1 # this would set the label of pixel 3,4 as 1
ann_img[ 0 , 0 ] = 2 # this would set the label of pixel 0,0 as 2
```

After generating the segmentation images, place them in the training/testing folder. Make separate folders for input images and the segmentation images. The file name of the input image and the corresponding segmentation image should be the same. For this tutorial we

would be using a data-set which is already prepared. You can download it from here (Aerial Semantic Segmentation Drone Dataset).

Aerial Semantic Segmentation Drone Dataset

```
from PIL import Image
import matplotlib.pyplot as plt
%matplotlib inline

original_image = "/kaggle/input/semantic-drone-dataset/dataset/semantic_drone_dataset/original_images/001.jpg"
label_image_semantic = "/kaggle/input/semantic-drone-dataset/dataset/semantic_drone_dataset/label_images_semantic/001.png"

fig, axs = plt.subplots(1, 2, figsize=(16, 8), constrained_layout=True)

axs[0].imshow( Image.open(original_image))
axs[0].grid(False)

label_image_semantic = Image.open(label_image_semantic)
label_image_semantic = np.asarray(label_image_semantic)
axs[1].imshow(label_image_semantic)
axs[1].grid(False)
```

2.Implementation of Segnet, FCN, UNet , PSPNet and other models in Keras

Source Github Link: https://github.com/divamgupta/image-segmentation-keras

Models Following models are supported:

model_name	Base Model	Segmentation Model
fcn_8	Vanilla CNN	FCN8
fcn_32	Vanilla CNN	FCN8
fcn_8_vgg	VGG 16	FCN8
fcn_32_vgg	VGG 16	FCN32
fcn_8_resnet50	Resnet-50	FCN32
fcn_32_resnet50	Resnet-50	FCN32
fcn_8_mobilenet	MobileNet	FCN32
fcn_32_mobilenet	MobileNet	FCN32
pspnet	Vanilla CNN	PSPNet
vgg_pspnet	VGG 16	PSPNet
resnet50_pspnet	Resnet-50	PSPNet

model_name	Base Model	Segmentation Model
unet_mini	Vanilla Mini CNN	U-Net
unet	Vanilla CNN	U-Net
vgg_unet	VGG 16	U-Net
resnet50_unet	Resnet-50	U-Net
mobilenet_unet	MobileNet	U-Net
segnet	Vanilla CNN	Segnet
vgg_segnet	VGG 16	Segnet
resnet50_segnet	Resnet-50	Segnet
mobilenet_segnet	MobileNet	Segnet

```
!pip install keras-segmentation
```

Train

```
kaggle_commit = True

epochs = 20
if kaggle_commit:
    epochs = 5


from keras_segmentation.models.unet import vgg_unet

n_classes = 23 # Aerial Semantic Segmentation Drone Dataset tree, gras, other vegetation, dirt, gravel, rocks, water, paved area, pool, person, dog, ca
model = vgg_unet(n_classes=n_classes ,  input_height=416, input_width=608  )

model.train(
    train_images =  "/kaggle/input/semantic-drone-dataset/dataset/semantic_drone_dataset/original_images/",
    train_annotations = "/kaggle/input/semantic-drone-dataset/dataset/semantic_drone_dataset/label_images_semantic/",
    checkpoints_path = "vgg_unet" , epochs=epochs
)
```

Prediction

```
import time
from PIL import Image
import matplotlib.pyplot as plt
%matplotlib inline
```

```
start = time.time()

input_image = "/kaggle/input/semantic-drone-dataset/dataset/semantic_drone_dataset/original_images/001.jpg"
out = model.predict_segmentation(
    inp=input_image,
    out_fname="out.png"
)

fig, axs = plt.subplots(1, 3, figsize=(20, 20), constrained_layout=True)

img_orig = Image.open(input_image)
axs[0].imshow(img_orig)
axs[0].set_title('original image-001.jpg')
axs[0].grid(False)

axs[1].imshow(out)
axs[1].set_title('prediction image-out.png')
axs[1].grid(False)

validation_image = "/kaggle/input/semantic-drone-dataset/dataset/semantic_drone_dataset/label_images_semantic/001.png"
axs[2].imshow( Image.open(validation_image))
axs[2].set_title('true label image-001.png')
axs[2].grid(False)

done = time.time()
elapsed = done - start


print(elapsed)
print(out)
print(out.shape)
```

3. I extracted Github codes

Implementation of Segnet, FCN, UNet , PSPNet and other models in Keras the codes in this section do everything for you. You have no chance to interfere with the codes. I extracted these codes and wrote them open and open. We will have the chance to trade on the model as we wish.

```
import os
os.environ['TF_CPP_MIN_LOG_LEVEL'] = '3'

import keras
from keras.models import *
```

```
from keras.layers import *

from types import MethodType
import random
import six
import json
from tqdm import tqdm
import cv2
import numpy as np
import itertools


import sys
print(sys.version)


IMAGE_ORDERING_CHANNELS_FIRST = "channels_first"
IMAGE_ORDERING_CHANNELS_LAST = "channels_last"
# Default IMAGE_ORDERING = channels_last
IMAGE_ORDERING = IMAGE_ORDERING_CHANNELS_LAST

if IMAGE_ORDERING == 'channels_first':
    MERGE_AXIS = 1
elif IMAGE_ORDERING == 'channels_last':
    MERGE_AXIS = -1

if IMAGE_ORDERING == 'channels_first':
    pretrained_url = "https://github.com/fchollet/deep-learning-models/" \
                     "releases/download/v0.1/" \
                     "vgg16_weights_th_dim_ordering_th_kernels_notop.h5"
elif IMAGE_ORDERING == 'channels_last':
    pretrained_url = "https://github.com/fchollet/deep-learning-models/" \
                     "releases/download/v0.1/" \
                     "vgg16_weights_tf_dim_ordering_tf_kernels_notop.h5"

class_colors = [(random.randint(0, 255), random.randint(
    0, 255), random.randint(0, 255)) for _ in range(5000)]




def get_colored_segmentation_image( seg_arr  , n_classes , colors=class_colors ):
    output_height = seg_arr.shape[0]
    output_width = seg_arr.shape[1]

    seg_img = np.zeros((output_height, output_width, 3))

    for c in range(n_classes):
```

```
        seg_img[:, :, 0] += ((seg_arr[:, :] == c)*(colors[c][0])).astype('uint8')
        seg_img[:, :, 1] += ((seg_arr[:, :] == c)*(colors[c][1])).astype('uint8')
        seg_img[:, :, 2] += ((seg_arr[:, :] == c)*(colors[c][2])).astype('uint8')

    return seg_img



def visualize_segmentation( seg_arr , inp_img=None  , n_classes=None ,
    colors=class_colors , class_names=None , overlay_img=False , show_legends=False ,
    prediction_width=None , prediction_height=None  ):


    if n_classes is None:
        n_classes = np.max(seg_arr)

    seg_img = get_colored_segmentation_image( seg_arr  , n_classes , colors=colors )

    if not inp_img is None:
        orininal_h = inp_img.shape[0]
        orininal_w = inp_img.shape[1]
        seg_img = cv2.resize(seg_img, (orininal_w, orininal_h))


    if (not prediction_height is None) and  (not prediction_width is None):
        seg_img = cv2.resize(seg_img, (prediction_width, prediction_height ))
        if not inp_img is None:
            inp_img = cv2.resize(inp_img, (prediction_width, prediction_height ))


    if overlay_img:
        assert not inp_img is None
        seg_img = overlay_seg_image( inp_img , seg_img  )


    if show_legends:
        assert not class_names is None
        legend_img = get_legends(class_names , colors=colors )

        seg_img = concat_lenends( seg_img , legend_img )


    return seg_img


def get_image_array(image_input, width, height, imgNorm="sub_mean",
                    ordering='channels_first'):
```

```
    """ Load image array from input """

    if type(image_input) is np.ndarray:
        # It is already an array, use it as it is
        img = image_input
    elif  isinstance(image_input, six.string_types)  :
        if not os.path.isfile(image_input):
            raise DataLoaderError("get_image_array: path {0} doesn't exist".format(image_input))
        img = cv2.imread(image_input, 1)
    else:
        raise DataLoaderError("get_image_array: Can't process input type {0}".format(str(type(image_input))))

    if imgNorm == "sub_and_divide":
        img = np.float32(cv2.resize(img, (width, height))) / 127.5 - 1
    elif imgNorm == "sub_mean":
        img = cv2.resize(img, (width, height))
        img = img.astype(np.float32)
        img[:, :, 0] -= 103.939
        img[:, :, 1] -= 116.779
        img[:, :, 2] -= 123.68
        img = img[:, :, ::-1]
    elif imgNorm == "divide":
        img = cv2.resize(img, (width, height))
        img = img.astype(np.float32)
        img = img/255.0

    if ordering == 'channels_first':
        img = np.rollaxis(img, 2, 0)
    return img

def get_image_arr( path , width , height , imgNorm="sub_mean" , odering='channels_first' ):

    if type( path ) is np.ndarray:
        img = path
    else:
        img = cv2.imread(path, 1)

    if imgNorm == "sub_and_divide":
        img = np.float32(cv2.resize(img, ( width , height ))) / 127.5 - 1
    elif imgNorm == "sub_mean":
        img = cv2.resize(img, ( width , height ))
        img = img.astype(np.float32)
        img[:,:,0] -= 103.939
        img[:,:,1] -= 116.779
        img[:,:,2] -= 123.68
        img = img[ : , : , ::-1 ]
    elif imgNorm == "divide":
```

```
        img = cv2.resize(img, ( width , height ))
        img = img.astype(np.float32)
        img = img/255.0

    if odering == 'channels_first':
        img = np.rollaxis(img, 2, 0)
    return img


def get_segmentation_array(image_input, nClasses, width, height, no_reshape=False):
    """ Load segmentation array from input """

    seg_labels = np.zeros((height, width, nClasses))

    if type(image_input) is np.ndarray:
        # It is already an array, use it as it is
        img = image_input
    elif isinstance(image_input, six.string_types) :
        if not os.path.isfile(image_input):
            raise DataLoaderError("get_segmentation_array: path {0} doesn't exist".format(image_input))
        img = cv2.imread(image_input, 1)
    else:
        raise DataLoaderError("get_segmentation_array: Can't process input type {0}".format(str(type(image_input))))

    img = cv2.resize(img, (width, height), interpolation=cv2.INTER_NEAREST)
    img = img[:, :, 0]

    for c in range(nClasses):
        seg_labels[:, :, c] = (img == c).astype(int)

    if not no_reshape:
        seg_labels = np.reshape(seg_labels, (width*height, nClasses))

    return seg_labels


def image_segmentation_generator(images_path, segs_path, batch_size,
                                 n_classes, input_height, input_width,
                                 output_height, output_width,
                                 do_augment=False ,augmentation_name="aug_all" ):

    img_seg_pairs = get_pairs_from_paths(images_path, segs_path)
    random.shuffle(img_seg_pairs)
    zipped = itertools.cycle(img_seg_pairs)

    while True:
        X = []
```

```
        Y = []
        for _ in range(batch_size):
            im, seg = next(zipped)

            im = cv2.imread(im, 1)
            seg = cv2.imread(seg, 1)

            if do_augment:
                im, seg[:, :, 0] = augment_seg(im, seg[:, :, 0] , augmentation_name=augmentation_name )

            X.append(get_image_array(im, input_width,
                                     input_height, ordering=IMAGE_ORDERING))
            Y.append(get_segmentation_array(
                seg, n_classes, output_width, output_height))

        yield np.array(X), np.array(Y)


def get_pairs_from_paths(images_path, segs_path, ignore_non_matching=False):
    """ Find all the images from the images_path directory and
        the segmentation images from the segs_path directory
        while checking integrity of data """

    ACCEPTABLE_IMAGE_FORMATS = [".jpg", ".jpeg", ".png" , ".bmp"]
    ACCEPTABLE_SEGMENTATION_FORMATS = [".png", ".bmp"]

    image_files = []
    segmentation_files = {}

    for dir_entry in os.listdir(images_path):
        if os.path.isfile(os.path.join(images_path, dir_entry)) and \
                os.path.splitext(dir_entry)[1] in ACCEPTABLE_IMAGE_FORMATS:
            file_name, file_extension = os.path.splitext(dir_entry)
            image_files.append((file_name, file_extension, os.path.join(images_path, dir_entry)))

    for dir_entry in os.listdir(segs_path):
        if os.path.isfile(os.path.join(segs_path, dir_entry)) and \
                os.path.splitext(dir_entry)[1] in ACCEPTABLE_SEGMENTATION_FORMATS:
            file_name, file_extension = os.path.splitext(dir_entry)
            if file_name in segmentation_files:
                raise DataLoaderError("Segmentation file with filename {0} already exists and is ambiguous to resolve with path {1}. Please remove or r
            segmentation_files[file_name] = (file_extension, os.path.join(segs_path, dir_entry))

    return_value = []
    # Match the images and segmentations
    for image_file, _, image_full_path in image_files:
        if image_file in segmentation_files:
```

```
            return_value.append((image_full_path, segmentation_files[image_file][1]))
        elif ignore_non_matching:
            continue
        else:
            # Error out
            raise DataLoaderError("No corresponding segmentation found for image {0}.".format(image_full_path))

    return return_value


def verify_segmentation_dataset(images_path, segs_path, n_classes, show_all_errors=False):
    try:
        img_seg_pairs = get_pairs_from_paths(images_path, segs_path)
        if not len(img_seg_pairs):
            print("Couldn't load any data from images_path: {0} and segmentations path: {1}".format(images_path, segs_path))
            return False

        return_value = True
        for im_fn, seg_fn in tqdm(img_seg_pairs):
            img = cv2.imread(im_fn)
            seg = cv2.imread(seg_fn)
            # Check dimensions match
            if not img.shape == seg.shape:
                return_value = False
                print("The size of image {0} and its segmentation {1} doesn't match (possibly the files are corrupt).".format(im_fn, seg_fn))
                if not show_all_errors:
                    break
            else:
                max_pixel_value = np.max(seg[:, :, 0])
                if max_pixel_value >= n_classes:
                    return_value = False
                    print("The pixel values of the segmentation image {0} violating range [0, {1}]. Found maximum pixel value {2}".format(seg_fn, str(n
                    if not show_all_errors:
                        break
        if return_value:
            print("Dataset verified! ")
        else:
            print("Dataset not verified!")
        return return_value
    except Exception as e:
        print("Found error during data loading\n{0}".format(str(e)))
        return False


def evaluate( model=None , inp_images=None , annotations=None,inp_images_dir=None ,annotations_dir=None , checkpoints_path=None ):

    if model is None:
```

```
        assert (checkpoints_path is not None) , "Please provide the model or the checkpoints_path"
        model = model_from_checkpoint_path(checkpoints_path)

    if inp_images is None:
        assert (inp_images_dir is not None) , "Please privide inp_images or inp_images_dir"
        assert (annotations_dir is not None) , "Please privide inp_images or inp_images_dir"

        paths = get_pairs_from_paths(inp_images_dir , annotations_dir )
        paths = list(zip(*paths))
        inp_images = list(paths[0])
        annotations = list(paths[1])

    assert type(inp_images) is list
    assert type(annotations) is list

    tp = np.zeros( model.n_classes  )
    fp = np.zeros( model.n_classes  )
    fn = np.zeros( model.n_classes  )
    n_pixels = np.zeros( model.n_classes  )

    for inp , ann   in tqdm( zip( inp_images , annotations )):
        pr = predict(model , inp )
        gt = get_segmentation_array( ann , model.n_classes ,  model.output_width , model.output_height , no_reshape=True  )
        gt = gt.argmax(-1)
        pr = pr.flatten()
        gt = gt.flatten()

        for cl_i in range(model.n_classes ):

            tp[ cl_i ] += np.sum( (pr == cl_i) * (gt == cl_i) )
            fp[ cl_i ] += np.sum( (pr == cl_i) * ((gt != cl_i)) )
            fn[ cl_i ] += np.sum( (pr != cl_i) * ((gt == cl_i)) )
            n_pixels[ cl_i ] += np.sum( gt == cl_i  )

    cl_wise_score = tp / ( tp + fp + fn + 0.000000000001 )
    n_pixels_norm = n_pixels /  np.sum(n_pixels)
    frequency_weighted_IU = np.sum(cl_wise_score*n_pixels_norm)
    mean_IU = np.mean(cl_wise_score)
    return {"frequency_weighted_IU":frequency_weighted_IU , "mean_IU":mean_IU , "class_wise_IU":cl_wise_score }


def predict_multiple(model=None, inps=None, inp_dir=None, out_dir=None,
                     checkpoints_path=None ,overlay_img=False ,
    class_names=None , show_legends=False , colors=class_colors , prediction_width=None , prediction_height=None  ):

    if model is None and (checkpoints_path is not None):
        model = model_from_checkpoint_path(checkpoints_path)
```

```
    if inps is None and (inp_dir is not None):
        inps = glob.glob(os.path.join(inp_dir, "*.jpg")) + glob.glob(
            os.path.join(inp_dir, "*.png")) + \
            glob.glob(os.path.join(inp_dir, "*.jpeg"))

    assert type(inps) is list

    all_prs = []

    for i, inp in enumerate(tqdm(inps)):
        if out_dir is None:
            out_fname = None
        else:
            if isinstance(inp, six.string_types):
                out_fname = os.path.join(out_dir, os.path.basename(inp))
            else:
                out_fname = os.path.join(out_dir, str(i) + ".jpg")

        pr = predict( model, inp, out_fname ,
            overlay_img=overlay_img,class_names=class_names ,show_legends=show_legends ,
            colors=colors , prediction_width=prediction_width , prediction_height=prediction_height  )

        all_prs.append(pr)

    return all_prs


def predict(model=None, inp=None, out_fname=None, checkpoints_path=None,overlay_img=False ,
    class_names=None , show_legends=False , colors=class_colors , prediction_width=None , prediction_height=None  ):

    if model is None and (checkpoints_path is not None):
        model = model_from_checkpoint_path(checkpoints_path)

    assert (inp is not None)
    assert((type(inp) is np.ndarray) or isinstance(inp, six.string_types)
           ), "Inupt should be the CV image or the input file name"

    if isinstance(inp, six.string_types):
        inp = cv2.imread(inp)

    assert len(inp.shape) == 3, "Image should be h,w,3 "
    orininal_h = inp.shape[0]
    orininal_w = inp.shape[1]

    output_width = model.output_width
    output_height = model.output_height
```

```
    input_width = model.input_width
    input_height = model.input_height
    n_classes = model.n_classes

    x = get_image_array(inp, input_width, input_height, ordering=IMAGE_ORDERING)
    pr = model.predict(np.array([x]))[0]
    pr = pr.reshape((output_height,  output_width, n_classes)).argmax(axis=2)

    seg_img = visualize_segmentation( pr , inp ,n_classes=n_classes , colors=colors
        , overlay_img=overlay_img ,show_legends=show_legends ,class_names=class_names ,prediction_width=prediction_width , prediction_height=prediction

    if out_fname is not None:
        cv2.imwrite(out_fname, seg_img)

    return pr



def train(model,
          train_images,
          train_annotations,
          input_height=None,
          input_width=None,
          n_classes=None,
          verify_dataset=True,
          checkpoints_path=None,
          epochs=5,
          batch_size=2,
          validate=False,
          val_images=None,
          val_annotations=None,
          val_batch_size=2,
          auto_resume_checkpoint=False,
          load_weights=None,
          steps_per_epoch=512,
          val_steps_per_epoch=512,
          gen_use_multiprocessing=False,
          ignore_zero_class=False ,
          optimizer_name='adadelta' , do_augment=False , augmentation_name="aug_all"
          ):


    # check if user gives model name instead of the model object
    if isinstance(model, six.string_types):
        # create the model from the name
        assert (n_classes is not None), "Please provide the n_classes"
        if (input_height is not None) and (input_width is not None):
```

```
        model = model_from_name[model](
            n_classes, input_height=input_height, input_width=input_width)
    else:
        model = model_from_name[model](n_classes)

n_classes = model.n_classes
input_height = model.input_height
input_width = model.input_width
output_height = model.output_height
output_width = model.output_width

if validate:
    assert val_images is not None
    assert val_annotations is not None

if optimizer_name is not None:

    if ignore_zero_class:
        loss_k = masked_categorical_crossentropy
    else:
        loss_k = 'categorical_crossentropy'

    model.compile(loss= loss_k ,
                  optimizer=optimizer_name,
                  metrics=['accuracy'])

if checkpoints_path is not None:
    with open(checkpoints_path+"_config.json", "w") as f:
        json.dump({
            "model_class": model.model_name,
            "n_classes": n_classes,
            "input_height": input_height,
            "input_width": input_width,
            "output_height": output_height,
            "output_width": output_width
        }, f)

if load_weights is not None and len(load_weights) > 0:
    print("Loading weights from ", load_weights)
    model.load_weights(load_weights)

if auto_resume_checkpoint and (checkpoints_path is not None):
    latest_checkpoint = find_latest_checkpoint(checkpoints_path)
    if latest_checkpoint is not None:
        print("Loading the weights from latest checkpoint ",
              latest_checkpoint)
        model.load_weights(latest_checkpoint)
```

```
    if verify_dataset:
        print("Verifying training dataset")
        verified = verify_segmentation_dataset(train_images, train_annotations, n_classes)
        assert verified
        if validate:
            print("Verifying validation dataset")
            verified = verify_segmentation_dataset(val_images, val_annotations, n_classes)
            assert verified

    train_gen = image_segmentation_generator(
        train_images, train_annotations,  batch_size,  n_classes,
        input_height, input_width, output_height, output_width , do_augment=do_augment ,augmentation_name=augmentation_name )

    if validate:
        val_gen = image_segmentation_generator(
            val_images, val_annotations,  val_batch_size,
            n_classes, input_height, input_width, output_height, output_width)

    if not validate:
        for ep in range(epochs):
            print("Starting Epoch ", ep)
            model.fit_generator(train_gen, steps_per_epoch, epochs=1, use_multiprocessing=True)
            if checkpoints_path is not None:
                model.save_weights(checkpoints_path + "." + str(ep))
                print("saved ", checkpoints_path + ".model." + str(ep))
            print("Finished Epoch", ep)
    else:
        for ep in range(epochs):
            print("Starting Epoch ", ep)
            model.fit_generator(train_gen, steps_per_epoch,
                                validation_data=val_gen,
                                validation_steps=val_steps_per_epoch,  epochs=1 , use_multiprocessing=gen_use_multiprocessing)
            if checkpoints_path is not None:
                model.save_weights(checkpoints_path + "." + str(ep))
                print("saved ", checkpoints_path + ".model." + str(ep))
            print("Finished Epoch", ep)



def get_segmentation_model(input, output):

    img_input = input
    o = output

    o_shape = Model(img_input, o).output_shape
    i_shape = Model(img_input, o).input_shape
```

```
    if IMAGE_ORDERING == 'channels_first':
        output_height = o_shape[2]
        output_width = o_shape[3]
        input_height = i_shape[2]
        input_width = i_shape[3]
        n_classes = o_shape[1]
        o = (Reshape((-1, output_height*output_width)))(o)
        o = (Permute((2, 1)))(o)
    elif IMAGE_ORDERING == 'channels_last':
        output_height = o_shape[1]
        output_width = o_shape[2]
        input_height = i_shape[1]
        input_width = i_shape[2]
        n_classes = o_shape[3]
        o = (Reshape((output_height*output_width, -1)))(o)

    o = (Activation('softmax'))(o)
    model = Model(img_input, o)
    model.output_width = output_width
    model.output_height = output_height
    model.n_classes = n_classes
    model.input_height = input_height
    model.input_width = input_width
    model.model_name = ""

    model.train = MethodType(train, model)
    model.predict_segmentation = MethodType(predict, model)
    model.predict_multiple = MethodType(predict_multiple, model)
    model.evaluate_segmentation = MethodType(evaluate, model)

    return model


def get_vgg_encoder(input_height=224,  input_width=224, pretrained='imagenet'):

    assert input_height % 32 == 0
    assert input_width % 32 == 0

    if IMAGE_ORDERING == 'channels_first':
        img_input = Input(shape=(3, input_height, input_width))
    elif IMAGE_ORDERING == 'channels_last':
        img_input = Input(shape=(input_height, input_width, 3))

    x = Conv2D(64, (3, 3), activation='relu', padding='same',
               name='block1_conv1', data_format=IMAGE_ORDERING)(img_input)
    x = Conv2D(64, (3, 3), activation='relu', padding='same',
```

```
           name='block1_conv2', data_format=IMAGE_ORDERING)(x)
x = MaxPooling2D((2, 2), strides=(2, 2), name='block1_pool',
                 data_format=IMAGE_ORDERING)(x)
f1 = x
# Block 2
x = Conv2D(128, (3, 3), activation='relu', padding='same',
           name='block2_conv1', data_format=IMAGE_ORDERING)(x)
x = Conv2D(128, (3, 3), activation='relu', padding='same',
           name='block2_conv2', data_format=IMAGE_ORDERING)(x)
x = MaxPooling2D((2, 2), strides=(2, 2), name='block2_pool',
                 data_format=IMAGE_ORDERING)(x)
f2 = x

# Block 3
x = Conv2D(256, (3, 3), activation='relu', padding='same',
           name='block3_conv1', data_format=IMAGE_ORDERING)(x)
x = Conv2D(256, (3, 3), activation='relu', padding='same',
           name='block3_conv2', data_format=IMAGE_ORDERING)(x)
x = Conv2D(256, (3, 3), activation='relu', padding='same',
           name='block3_conv3', data_format=IMAGE_ORDERING)(x)
x = MaxPooling2D((2, 2), strides=(2, 2), name='block3_pool',
                 data_format=IMAGE_ORDERING)(x)
f3 = x

# Block 4
x = Conv2D(512, (3, 3), activation='relu', padding='same',
           name='block4_conv1', data_format=IMAGE_ORDERING)(x)
x = Conv2D(512, (3, 3), activation='relu', padding='same',
           name='block4_conv2', data_format=IMAGE_ORDERING)(x)
x = Conv2D(512, (3, 3), activation='relu', padding='same',
           name='block4_conv3', data_format=IMAGE_ORDERING)(x)
x = MaxPooling2D((2, 2), strides=(2, 2), name='block4_pool',
                 data_format=IMAGE_ORDERING)(x)
f4 = x

# Block 5
x = Conv2D(512, (3, 3), activation='relu', padding='same',
           name='block5_conv1', data_format=IMAGE_ORDERING)(x)
x = Conv2D(512, (3, 3), activation='relu', padding='same',
           name='block5_conv2', data_format=IMAGE_ORDERING)(x)
x = Conv2D(512, (3, 3), activation='relu', padding='same',
           name='block5_conv3', data_format=IMAGE_ORDERING)(x)
x = MaxPooling2D((2, 2), strides=(2, 2), name='block5_pool',
                 data_format=IMAGE_ORDERING)(x)
f5 = x

if pretrained == 'imagenet':
```

```
        VGG_Weights_path = keras.utils.get_file(pretrained_url.split("/")[-1], pretrained_url)
        Model(img_input, x).load_weights(VGG_Weights_path)

    return img_input, [f1, f2, f3, f4, f5]


def _unet(n_classes, encoder, l1_skip_conn=True, input_height=416,
          input_width=608):

    img_input, levels = encoder(
        input_height=input_height, input_width=input_width)
    [f1, f2, f3, f4, f5] = levels

    o = f4

    o = (ZeroPadding2D((1, 1), data_format=IMAGE_ORDERING))(o)
    o = (Conv2D(512, (3, 3), padding='valid', data_format=IMAGE_ORDERING))(o)
    o = (BatchNormalization())(o)

    o = (UpSampling2D((2, 2), data_format=IMAGE_ORDERING))(o)
    o = (concatenate([o, f3], axis=MERGE_AXIS))
    o = (ZeroPadding2D((1, 1), data_format=IMAGE_ORDERING))(o)
    o = (Conv2D(256, (3, 3), padding='valid', data_format=IMAGE_ORDERING))(o)
    o = (BatchNormalization())(o)

    o = (UpSampling2D((2, 2), data_format=IMAGE_ORDERING))(o)
    o = (concatenate([o, f2], axis=MERGE_AXIS))
    o = (ZeroPadding2D((1, 1), data_format=IMAGE_ORDERING))(o)
    o = (Conv2D(128, (3, 3), padding='valid', data_format=IMAGE_ORDERING))(o)
    o = (BatchNormalization())(o)

    o = (UpSampling2D((2, 2), data_format=IMAGE_ORDERING))(o)

    if l1_skip_conn:
        o = (concatenate([o, f1], axis=MERGE_AXIS))

    o = (ZeroPadding2D((1, 1), data_format=IMAGE_ORDERING))(o)
    o = (Conv2D(64, (3, 3), padding='valid', data_format=IMAGE_ORDERING))(o)
    o = (BatchNormalization())(o)

    o = Conv2D(n_classes, (3, 3), padding='same',data_format=IMAGE_ORDERING)(o)

    model = get_segmentation_model(img_input, o)

    return model
```

```
def vgg_unet(n_classes, input_height=416, input_width=608, encoder_level=3):

    model = _unet(n_classes, get_vgg_encoder,input_height=input_height, input_width=input_width)
    model.model_name = "vgg_unet"
    return model

n_classes = 23 # Aerial Semantic Segmentation Drone Dataset tree, gras, other vegetation, dirt, gravel, rocks, water, paved area, pool, person, dog, ca

model = vgg_unet(n_classes=n_classes,  input_height=416, input_width=608)
model_from_name = {}
model_from_name["vgg_unet"] = vgg_unet
```

Train

```
kaggle_commit = True

epochs = 20
if kaggle_commit:
    epochs = 5
```

```
model.train(
    train_images =  "/kaggle/input/semantic-drone-dataset/dataset/semantic_drone_dataset/original_images/",
    train_annotations = "/kaggle/input/semantic-drone-dataset/dataset/semantic_drone_dataset/label_images_semantic/",
    checkpoints_path = "vgg_unet" , epochs=epochs
)
```

Prediction

```
from PIL import Image
import matplotlib.pyplot as plt
%matplotlib inline

start = time.time()

input_image = "/kaggle/input/semantic-drone-dataset/dataset/semantic_drone_dataset/original_images/002.jpg"
out = model.predict_segmentation(
    inp=input_image,
    out_fname="out.png"
)
```

```
fig, axs = plt.subplots(1, 3, figsize=(20, 20), constrained_layout=True)

img_orig = Image.open(input_image)
axs[0].imshow(img_orig)
axs[0].set_title('original image-002.jpg')
axs[0].grid(False)

axs[1].imshow(out)
axs[1].set_title('prediction image-out.png')
axs[1].grid(False)

validation_image = "/kaggle/input/semantic-drone-dataset/dataset/dataset/semantic_drone_dataset/label_images_semantic/002.png"
axs[2].imshow( Image.open(validation_image))
axs[2].set_title('true label image-002.png')
axs[2].grid(False)


done = time.time()
elapsed = done - start


print(elapsed)
print(out)
print(out.shape)
```