In [1]:
```
!wget --header 'Host: storage.googleapis.com' --user-agent 'Mozilla/5.0 (X11; Ubuntu; Linux x86_64; rv:87.0) Gecko/20100
!pip install q keras==2.4.1
!pip install segmentation_models
!pip install tensorflow_io
!unzip '/content/ultrasound-nerve-segmentation.zip'
```

In [2]:
```
import os
import re
import random
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import re
import seaborn as sns
import cv2
from PIL import Image
from sklearn.model_selection import train_test_split, KFold
import tensorflow_io as tfio
import keras
import tensorflow as tf
# tf.compat.v1.enable_eager_execution()
from tensorflow import keras
from tensorflow.keras.layers import *
from tensorflow.keras.preprocessing import image
from tensorflow.keras.models import Model, load_model
from tensorflow.keras.layers import UpSampling2D
from tensorflow.keras.layers import MaxPooling2D, GlobalAveragePooling2D
from tensorflow.keras.layers import concatenate,Dropout
from tensorflow.keras.layers import Multiply, MaxPooling2D, GlobalMaxPooling2D
from tensorflow.keras.callbacks import EarlyStopping, ModelCheckpoint
from tensorflow.keras import backend as K
from tensorflow.keras.layers import Input, Add, Dense, Activation, ZeroPadding2D
from tensorflow.keras.layers import BatchNormalization, Flatten, Conv2D, AveragePooling2D
from tensorflow.keras.models import Model, load_model
from tensorflow.keras.callbacks import EarlyStopping, ModelCheckpoint, ReduceLROnPlateau
from tensorflow.keras.utils import plot_model
from tensorflow.keras.initializers import glorot_uniform
from tensorflow.keras.optimizers import Adam
from tensorflow.keras.utils import plot_model
from keras.callbacks import ModelCheckpoint
import tensorflow
import keras
import cv2
import imgaug.augmenters as iaa
os.environ['TF_FORCE_GPU_ALLOW_GROWTH'] = 'true'
import segmentation_models as sm
from segmentation_models.metrics import iou_score
from segmentation_models import Unet
focal_loss = sm.losses.cce_dice_loss
import random
import segmentation_models as sm
from segmentation_models import Unet
# sm.set_framework('tf.keras')
tf.keras.backend.set_image_data_format('channels_last')
```

```
Using TensorFlow backend.
Segmentation Models: using `keras` framework.
```

In [5]:
```
img=pd.read_csv('/content/drive/MyDrive/dup_rem.csv')
df=pd.read_csv('/content/train_masks.csv')
img.drop('Unnamed: 0',axis=1,inplace=True)
img.image_name=img.image_name.astype(int)
img.subject_name=img.subject_name.astype(int)
img.columns=['image_path','img','subject','mask_path']
new_df=pd.merge(img,df,on=['img','subject'])
new_df.pixels.fillna(0,inplace=True)
val=[0 if i==0 else 1 for i in new_df.pixels]
new_df['mask_pres']=val
```

In [6]:
```
pos_df=new_df[new_df.mask_pres==1]
```

In [7]:
```
X_train, X_valid, y_train, y_valid = train_test_split(pos_df.image_path, pos_df.mask_path, test_size=0.2, random_state=4
```

In [4]:
```
from google.colab import drive
drive.mount('/content/drive')
```

```
Mounted at /content/drive
```

In [8]:
```
im_height=128
im_width=128
```

In [9]:
```
def atrous_block(input):
  '''Implement DAC block as given in paper'''
  q1=Conv2D(filters=512,kernel_size=(3,3),padding='same',strides=1,name='atr0',dilation_rate=1,activation='relu')(input)
  q2=Conv2D(filters=512,kernel_size=(3,3),padding='same',strides=1,name='atr1',dilation_rate=2,activation='relu')(input)
  q2=Conv2D(filters=512,kernel_size=(1,1),padding='same',strides=1,name='atr2',dilation_rate=1,activation='relu')(q2)
  q3=Conv2D(filters=512,kernel_size=(3,3),padding='same',strides=1,name='atr3',dilation_rate=1,activation='relu')(input)
  q3=Conv2D(filters=512,kernel_size=(3,3),padding='same',strides=1,name='atr4',dilation_rate=2,activation='relu')(q3)
  q3=Conv2D(filters=512,kernel_size=(1,1),padding='same',strides=1,name='atr5',dilation_rate=1,activation='relu')(q3)
  q4=Conv2D(filters=512,kernel_size=(3,3),padding='same',strides=1,name='atr6',dilation_rate=1,activation='relu')(input)
  q4=Conv2D(filters=512,kernel_size=(3,3),padding='same',strides=1,name='atr7',dilation_rate=2,activation='relu')(q4)
  q4=Conv2D(filters=512,kernel_size=(3,3),padding='same',strides=1,name='atr8',dilation_rate=4,activation='relu')(q4)
```

```
    q4=Conv2D(filters=512,kernel_size=(1,1),padding='same',strides=1,name='atr9',dilation_rate=1,activation='relu')(q4)
    atr_out=concatenate([q1,q2,q3,q4],axis=-1)
    print(atr_out.shape)
    return atr_out
```

In [10]:
```
def rmp_block(input):
    '''Implement RMP block as given in paper'''
    X1=MaxPooling2D((2,2),strides=(2,2))(input)
    X1=Conv2DTranspose(512,(2,2),padding='same',activation='relu',strides=(2,2))(X1)
    X2=MaxPooling2D((3,3),strides=(2,2),padding='same')(input)
    X2=Conv2DTranspose(512,(3,3),padding='same',activation='relu',strides=(2,2))(X2)
    X3=MaxPooling2D((5,5),strides=(2,2),padding='same')(input)
    X3=Conv2DTranspose(512,(5,5),padding='same',activation='relu',strides=(2,2))(X3)
    X4=MaxPooling2D((6,6),strides=(2,2),padding='same')(input)
    X4=Conv2DTranspose(512,(6,6),padding='same',activation='relu',strides=(2,2))(X4)
    concat=concatenate([X1,X2,X3,X4],axis=-1)
    return concat
```

In [11]:
```
def convolutional_block(input, filters=3, kernel_size=3, batchnorm = True):
    #conv layer followed by batchnormalization
    x = Conv2D(filters = filters, kernel_size = (kernel_size, kernel_size),
               kernel_initializer = 'he_normal', padding = 'same')(input)
    if batchnorm:
        x = BatchNormalization()(x)
    x = Activation('relu')(x)
    x = Conv2D(filters = filters, kernel_size = (kernel_size, kernel_size),
               kernel_initializer = 'he_normal', padding = 'same')(input)
    if batchnorm:
        x = BatchNormalization()(x)
    x = Activation('relu')(x)
    return x
```

In [12]:
```
def resunet_opt(input_img, filters = 64, dropout = 0.2, batchnorm = True):
    """Residual Unet + Dense Atrous convolution + Rmp block"""
    conv1 = convolutional_block(input_img, filters * 1, kernel_size = 3, batchnorm = batchnorm)
    pool1 = MaxPooling2D((2, 2))(conv1)
    drop1 = Dropout(dropout)(pool1)

    conv2 = convolutional_block(drop1, filters * 2, kernel_size = 3, batchnorm = batchnorm)
    pool2 = MaxPooling2D((2, 2))(conv2)
    drop2 = Dropout(dropout)(pool2)

    conv3 = convolutional_block(drop2, filters * 4, kernel_size = 3, batchnorm = batchnorm)
    pool3 = MaxPooling2D((2, 2))(conv3)
    drop3 = Dropout(dropout)(pool3)

    conv4 = convolutional_block(drop3, filters * 8, kernel_size = 3, batchnorm = batchnorm)
    pool4 = MaxPooling2D((2, 2))(conv4)
    drop4 = Dropout(dropout)(pool4)

    conv5 = convolutional_block(drop4, filters = filters * 16, kernel_size = 3, batchnorm = batchnorm)
    #atrous conv or dillated conv is when filter has holes in it.
    conv5=atrous_block(conv5)
    conv5 = convolutional_block(conv5, filters = filters * 16, kernel_size = 3, batchnorm = batchnorm)
    conv5=rmp_block(conv5)
    conv5 = convolutional_block(conv5, filters = filters * 16, kernel_size = 3, batchnorm = batchnorm)

    ups6 = Conv2DTranspose(filters * 8, (3, 3), strides = (2, 2), padding = 'same',activation='relu',kernel_initializer=
    ups6 = concatenate([ups6, conv4])
    ups6 = Dropout(dropout)(ups6)
    conv6 = convolutional_block(ups6, filters * 8, kernel_size = 3, batchnorm = batchnorm)

    ups7 = Conv2DTranspose(filters * 4, (3, 3), strides = (2, 2), padding = 'same',activation='relu',kernel_initializer=
    ups7 = concatenate([ups7, conv3])
    ups7 = Dropout(dropout)(ups7)
    conv7 = convolutional_block(ups7, filters * 4, kernel_size = 3, batchnorm = batchnorm)

    ups8 = Conv2DTranspose(filters * 2, (3, 3), strides = (2, 2), padding = 'same',activation='relu',kernel_initializer=
    ups8 = concatenate([ups8, conv2])
    ups8 = Dropout(dropout)(ups8)
    conv8 = convolutional_block(ups8, filters * 2, kernel_size = 3, batchnorm = batchnorm)

    ups9 = Conv2DTranspose(filters * 1, (3, 3), strides = (2, 2), padding = 'same',activation='relu',kernel_initializer=
    ups9 = concatenate([ups9, conv1])
    ups9 = Dropout(dropout)(ups9)
    conv9 = convolutional_block(ups9, filters * 1, kernel_size = 3, batchnorm = batchnorm)

    outputs = Conv2D(4, (1, 1), activation='sigmoid')(conv9)
    model = Model(inputs=[input_img], outputs=[outputs])
    return model
```

In [13]:
```
def tfdata_generator(images, maskname, is_training, batch_size=64):
    '''Construct a data generator using tf.Dataset'''

    def parse_function(filename,maskname):
        #reading path
        image_string = tf.io.read_file(filename)
        #decoding image
        image = tfio.experimental.image.decode_tiff(image_string)

        # This will convert to float values in [0, 1]
        image = tf.image.convert_image_dtype(image, tf.float32)

        image = tf.image.resize(image, [im_height, im_width])
```

```
        mask=tf.io.read_file(maskname)
        mask=tfio.experimental.image.decode_tiff(mask)
        mask = tf.image.convert_image_dtype(mask, tf.float32)
        mask = tf.image.resize(mask, [im_height, im_width],method='nearest')
        return image,mask

    def flip_lr(image,labels):

        image = tf.image.flip_left_right(image)
        labels = tf.image.flip_left_right(labels)

        return image,labels
    def flip_ud(image,labels):

        image = tf.image.flip_up_down(image)
        labels = tf.image.flip_up_down(image)

        return image,labels

    def rotate(image,labels):
        val=tf.random.uniform(shape=[], minval=0, maxval=4, dtype=tf.int32)
        return tf.image.rot90(image, val),tf.image.rot90(labels,val)


    dataset = tf.data.Dataset.from_tensor_slices((images,maskname))

    if is_training:
        dataset = dataset.shuffle(5000)  # depends on sample size

    # Transform and batch data at the same time
    dataset = dataset.apply(tf.data.experimental.map_and_batch( parse_function, batch_size,num_parallel_batches=4,  # cp
        drop_remainder=True if is_training else False))
    # augmentations = [flip,rotate]

    if is_training:
      if np.random.uniform(0,1)<0.2:
          dataset = dataset.map(flip_lr)
      elif np.random.uniform(0,1)<0.4:
          dataset = dataset.map(flip_ud)
      elif np.random.uniform(0,1)<0.5:
          dataset = dataset.map(rotate)
    dataset = dataset.repeat()

    dataset = dataset.prefetch(tf.data.experimental.AUTOTUNE)
    return dataset
```

In [14]:
```
tf.keras.backend.clear_session()
tr_image_generator = tfdata_generator(X_train,y_train, is_training=True, batch_size=64)
val_image_generator = tfdata_generator(X_valid,y_valid, is_training=False, batch_size=64)
```

```
WARNING:tensorflow:From <ipython-input-13-b5dfc2229dbd>:46: map_and_batch (from tensorflow.python.data.experimental.o
ps.batching) is deprecated and will be removed in a future version.
Instructions for updating:
Use `tf.data.Dataset.map(map_func, num_parallel_calls)` followed by `tf.data.Dataset.batch(batch_size, drop_remainde
r)`. Static tf.data optimizations will take care of using the fused implementation.
```

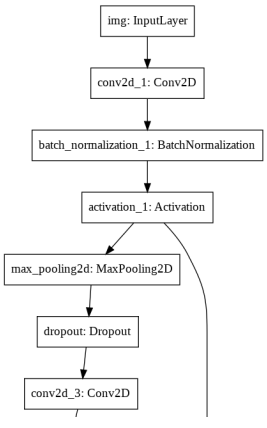
In [15]:
```
from datetime import datetime
logdir = "logs/scalars/" + datetime.now().strftime("%Y%m%d-%H%M%S")
tensorboard_callback = keras.callbacks.TensorBoard(log_dir=logdir,histogram_freq=1, write_graph=True,write_grads=True)
callbacks = [
    ModelCheckpoint('best_model.h5', verbose=1, save_best_only=True, save_weights_only=False),
    tensorboard_callback]
```

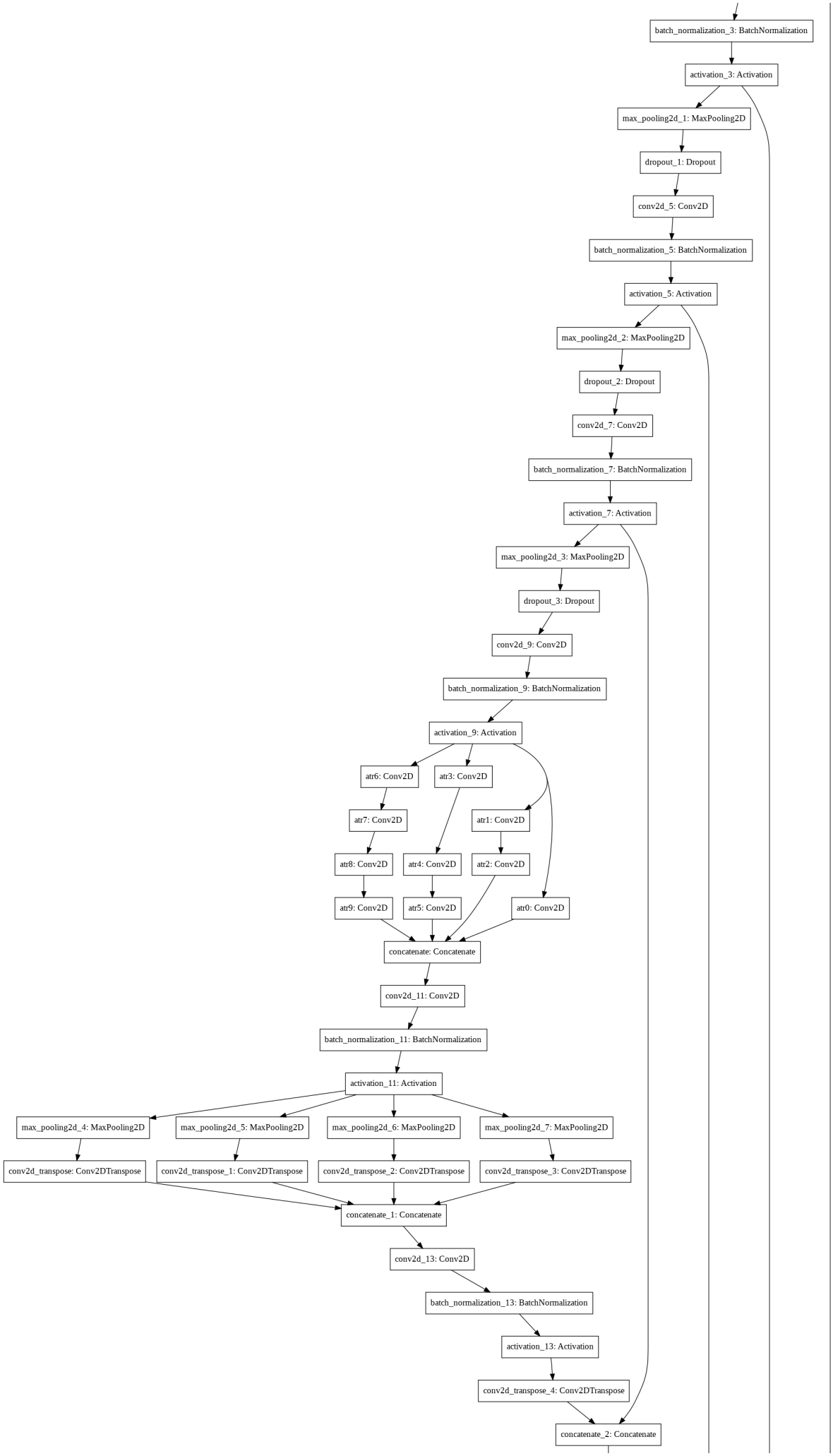
```
/usr/local/lib/python3.7/dist-packages/keras/callbacks/tensorboard_v2.py:97: UserWarning: The TensorBoard callback do
es not support gradients display when using TensorFlow 2.0. The `write_grads` argument is ignored.
  warnings.warn('The TensorBoard callback does not support '
```

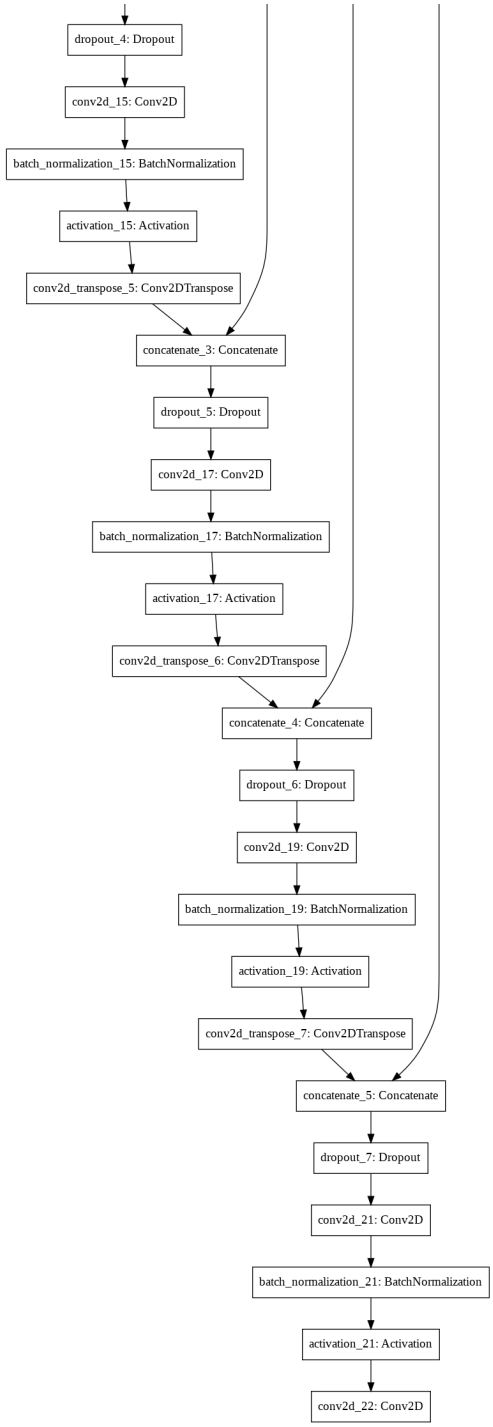
In [21]:
```
# im_height=128
# im_width=128
# input_img = Input((im_height, im_width,4), name='img')
# model = resunet_opt(input_img, filters=16, dropout=0.4, batchnorm=True)
model.compile(optimizer=Adam(lr=1e-5), loss=focal_loss, metrics=[iou_score])
```

In [ ]:
```
plot_model(model, to_file='model.png', show_shapes=False, show_dtype=False,
    show_layer_names=True, rankdir='TB', expand_nested=False, dpi=96)
```

Out[ ]:




batch_normalization_3: BatchNormalization
activation_3: Activation
max_pooling2d_1: MaxPooling2D
dropout_1: Dropout
conv2d_5: Conv2D
batch_normalization_5: BatchNormalization
activation_5: Activation
max_pooling2d_2: MaxPooling2D
dropout_2: Dropout
conv2d_7: Conv2D
batch_normalization_7: BatchNormalization
activation_7: Activation
max_pooling2d_3: MaxPooling2D
dropout_3: Dropout
conv2d_9: Conv2D
batch_normalization_9: BatchNormalization
activation_9: Activation
atr6: Conv2D
atr3: Conv2D
atr7: Conv2D
atr1: Conv2D
atr8: Conv2D
atr4: Conv2D
atr2: Conv2D
atr9: Conv2D
atr5: Conv2D
atr0: Conv2D
concatenate: Concatenate
conv2d_11: Conv2D
batch_normalization_11: BatchNormalization
activation_11: Activation
max_pooling2d_4: MaxPooling2D
max_pooling2d_5: MaxPooling2D
max_pooling2d_6: MaxPooling2D
max_pooling2d_7: MaxPooling2D
conv2d_transpose: Conv2DTranspose
conv2d_transpose_1: Conv2DTranspose
conv2d_transpose_2: Conv2DTranspose
conv2d_transpose_3: Conv2DTranspose
concatenate_1: Concatenate
conv2d_13: Conv2D
batch_normalization_13: BatchNormalization
activation_13: Activation
conv2d_transpose_4: Conv2DTranspose
concatenate_2: Concatenate



In [26]:
```
result=model.fit(tr_image_generator,steps_per_epoch=64,epochs=45,validation_data=val_image_generator,validation_steps=64
```

```
Epoch 36/45
64/64 [==============================] - 67s 1s/step - loss: 0.2333 - iou_score: 0.7139 - val_loss: 0.2397 - val_iou_
score: 0.7028

Epoch 00036: val_loss did not improve from 0.23898
Epoch 37/45
64/64 [==============================] - 64s 1s/step - loss: 0.2358 - iou_score: 0.7114 - val_loss: 0.2389 - val_iou_
score: 0.7039

Epoch 00037: val_loss improved from 0.23898 to 0.23891, saving model to best_model.h5
Epoch 38/45
64/64 [==============================] - 64s 1s/step - loss: 0.2362 - iou_score: 0.7109 - val_loss: 0.2399 - val_iou_
score: 0.7028

Epoch 00038: val_loss did not improve from 0.23891
Epoch 39/45
64/64 [==============================] - 64s 1s/step - loss: 0.2351 - iou_score: 0.7120 - val_loss: 0.2398 - val_iou_
score: 0.7028

Epoch 00039: val_loss did not improve from 0.23891
Epoch 40/45
64/64 [==============================] - 64s 1s/step - loss: 0.2352 - iou_score: 0.7119 - val_loss: 0.2390 - val_iou_
score: 0.7038

Epoch 00040: val_loss did not improve from 0.23891
Epoch 41/45
64/64 [==============================] - 64s 999ms/step - loss: 0.2332 - iou_score: 0.7142 - val_loss: 0.2386 - val_i
ou_score: 0.7041
```

```
Epoch 00041: val_loss improved from 0.23891 to 0.23862, saving model to best_model.h5
Epoch 42/45
64/64 [==============================] - 64s 1s/step - loss: 0.2344 - iou_score: 0.7133 - val_loss: 0.2392 - val_iou_
score: 0.7034

Epoch 00042: val_loss did not improve from 0.23862
Epoch 43/45
64/64 [==============================] - 63s 997ms/step - loss: 0.2343 - iou_score: 0.7130 - val_loss: 0.2389 - val_i
ou_score: 0.7041

Epoch 00043: val_loss did not improve from 0.23862
Epoch 44/45
64/64 [==============================] - 63s 992ms/step - loss: 0.2331 - iou_score: 0.7146 - val_loss: 0.2392 - val_i
ou_score: 0.7036

Epoch 00044: val_loss did not improve from 0.23862
Epoch 45/45
64/64 [==============================] - 65s 1s/step - loss: 0.2343 - iou_score: 0.7129 - val_loss: 0.2390 - val_iou_
score: 0.7039

Epoch 00045: val_loss did not improve from 0.23862
```

In [ ]:
```
model.load_weights('best_model.h5')
```