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DLRV Project Report

Semantic Segmentation of aerial images of forest scenery

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Contents

1 Introduction

Loss of forest area in Germany is taking place at a high rate and due to factors like lack of rainfall, the spruce bark beetle is infesting and destroying forests in Germany. To overcome this and to achieve reforestation at a large scale, measures must be taken that can be completed quickly and automatically which would be faster than doing it manually. Nowadays, unmanned Aerial Vehicles (UAVs) or drones are common in various applications such as aerial photography, agriculture, surveillance, product deliveries. UAVs can capture images by which users can generate high resolution images.

The above problem of loss of forest cover at a large scale has been identified and a project is in progress by a team at our university. The project is named Garrulus and details can be found on their website [1]. Garrulus is a project with the aim to reforest damaged forest area using UAVs. The prototype of the UAV would be surveying the terrain and would identify areas that are suitable for planting. Deep Learning is a field used for terrain surveillance and can provide relevant information. Image segmentation is a subpart of deep learning and is used to label the pixels of an image into different classes. Using image segmentation on aerial images captured by the drone is an approach to understand the terrain and plan the suitable land for reforestation.

1.1 Problem Formulation

Rapidly changing environment is mainly related due to the deforestation of the land due to various purposes by the humans. Global warming and effected bio-diversity are two major prominent effects of deforestation problems but, there are others as well such as desertification, flooding, soil erosion, increased greenhouse gases, and fewer crops etc [2]. In order to restore the environment forestation of the land is very important. Autonomous seeding of the deforested land has appeared to be a potential solution for effective forestation of available land. Seeding requires specific land with certain specific conditions to be successful. UAVs can be a potential solution for autonomously seeding the land for effective forestation. It is important for autonomous seeding agents such as UAVs to autonomously detect the potential

(a) Easily distinguishable regions (b) Not easily distinguishable regions

Figure 1: Sample data

spots for seeding with high rates of success. The main underlying problem is that how a UAV find a potential spot for seeding. A UAV collect aerial view of the terrain throughout the flight so there should be a way for a UAV to distinguish a potential spot within a generic aerial scenery of the area. A major problem can be locating and identify area of interest in aerial images under different conditions such as uneven illumination, low levels of contrast, or partially restricted visibility of the potential land in images. Aerial images of forest are very dense and there are marginal apparent differences between forest and available land due to other greenery in the environment, so it becomes a difficult problem to distinguish among a different part of forest i.e., forest and available land as shown in figure 1a and 1b.

1.2 Semantic Segmentation

Semantic segmentation refers to labelling each pixel of an image to a particular class. The figure 2 shows an example of a 2D image being classified into classes. In order to distinguish between forest and non forest area, semantic segmentation can be used to classify aerial images and decide the suitable area for reforestation. Architectures such as Fully Convolutional Neural Networks, U-Net are used for semantic segmentation.

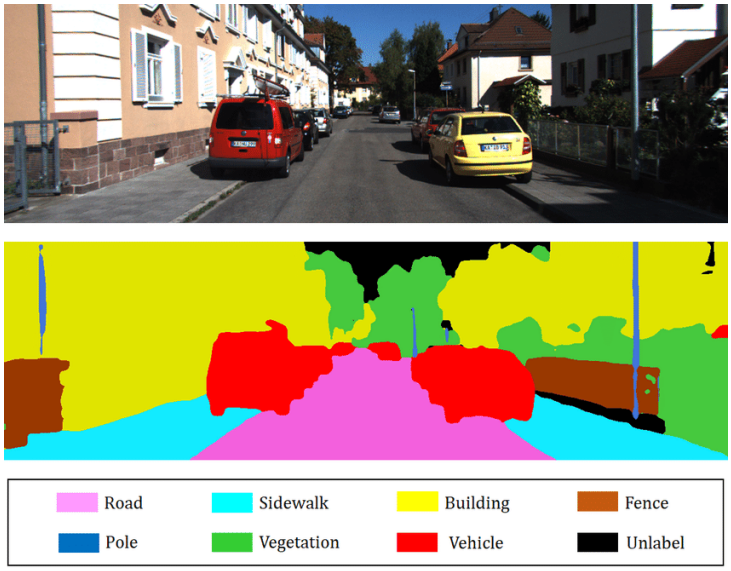

Figure 2: Semantic Segmentation as shown in [3]

2 Related Work

2.1 Convolutional Neural Networks

Convolutional Neural Networks (CNNs) are deep learning architectures that use layers to implement convolutions on the images in order to extract relevant features. They consist of convolutional layer, pooling layer and a fully connected layer. The first breakthrough using CNNs was the AlexNet architecture [4] for the ImageNet challenge.

The architecture that further improved on this was the VGG architecture that made use of deeper layers than AlexNet in order to get better results. [5]. The most well known architectures are the VGG-16 and VGG-19. The performance was further improved by Inception [6]. The inceptioon architecture went deeper and each layer had different convolutions to extract different features which were passed on the next layer with the help of a filter. But going deeper was only successful till a certain point and the performance was saturated. But the performance was improved by ResNet [7] where the authors did not go deeper but instead used skip connections in order to retain the "identity" or the relevant features.

2.2 Fully Convolutional Network

CNNs were designed for recognition of images and assigning a label to the image. Using the convolutional neural network for semantic segmentation was a bottleneck at the fully connected layer because this layer mixes the information from the entire image while getting the output. Therefore the convolutional neural network was modified for the application of semantic segmentation and called Fully Convolutional Network (FCN).[8] In this architecture, there is a downsampling path that extracts the relevant features, and an upsampling path which helps in localisation. Instead of the fully connected layer, there is a set of 1x1 kernel convolutions. FCNs employ skip connections to retain the information that was lost in the downsampling path. The authors mention that this helps in using images of arbitrary size.

2.3 U-Net

An example of an FCN is an architecture called U-Net. The name is because of the shape of the architecture as can be seen in the figure 3

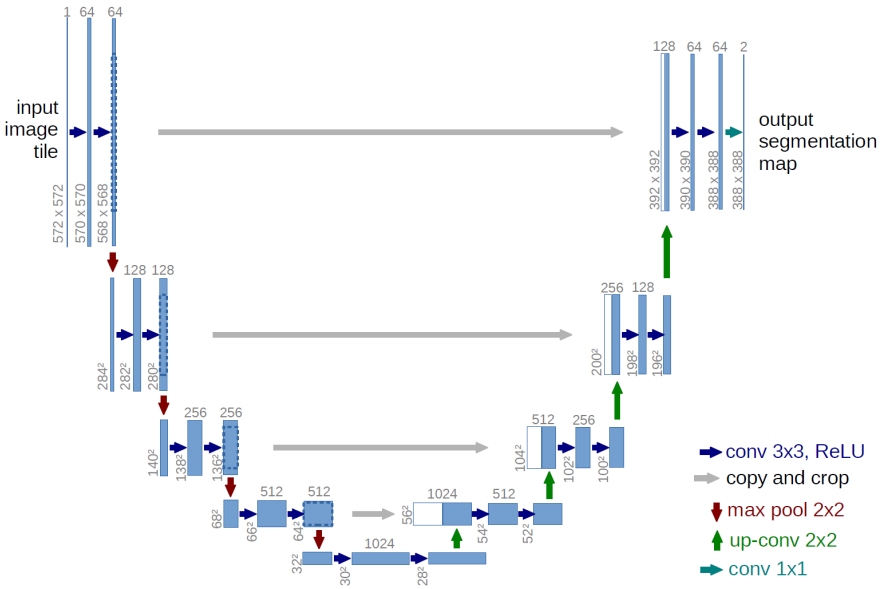

Figure 3: U-Net Architecture [9]

This architecture was initially designed for biomedical image segmentation and is an improvement on the FCN architecture. [9] It has become a popular choice

for image segmentation as it requires fewer training images. This architecture consists of an encoder and a decoder part and these are connected by a bridge in the bottom-most part of the image.

Encoder Network: This network extracts features with a sequence of encoder blocks. In the figure above this consists of a 3x3 convolution, then a ReLU activation function and then a max pooling layer. While going down the encoder or the contracting path, the dimensions are halved as compared to the previous layer and the feature channels are doubled.

Skip Connection: From the activation function of each layer of the encoder network, the output generated is used and concatenated to the corresponding layer of the decoder network. These connections are useful as they retain features that are useful in obtaining better semantic maps.

Decoder Network: In the decoder network, the semantic segmentation mask is generated. A 2x2 upscale convolution is performed. The skip connection is concatenated to each layer of the decoder network. Then two 3x3 convolutions are used and a ReLU activation function follows the skip connection. In this network, the dimensions are doubled while the feature channels are reduced by half. The last decoder goes through a 1x1 convolution with sigmoid activation. This function gives the segmentation mask representing the classification.

Bridge: This connects the encoder and decoder part. It has two 3x3 convolutions, and each convolution is followed by a ReLU activation function.

3 Methodology

3.1 Steps and deliverables

The code for this project is available at **Deep Learning for segmentation** The instructions to run the code is written in the "ReadMe" file of the repository

The adopted methodology involves semantic segmentation of the aerial images of forest using deep learning techniques using ensembling of 3 different U-Net architectures with different backbones. The implementation consists of 4 major steps as shown in Figure 4. 1st step consists of loading the training images along with their labelled masks and resize to cope with limited memory of the system. 2nd step is learning a good deep model capable of effective pixelwise classification of an image. In in last step trained model is then evaluated for accuracy of detection as well as localization of regions belonging to the non-forest areas in the images.

Figure 4: Project steps

3.2 Data Pre-processing

The dataset used for model training and evaluation consists of 5108 aerial images of dimensions 256x256. The dataset is obtained from land cover classification track in **DeepGlobe Challenge** . Each image has been provided with a binary mask image as label for the image the defines region of interest to distinguish between forest and non-forest regions in the image.

The size of the data set was increased by creating augmented images of the data set. The resulting data set contained 25,540 images. The following data augmentations were done

- Rotation randomly between -180 and 180 degrees
- Horizontal flip

- Vertical flip
- Vertical shift randomly between -64 and 64
- Horizontal shift randomly between -64 and 64

Each of the above 5 augmentations were performed on all the images and hence the data set was increased five fold

3.3 Model learning

Model Architecture

Model trained for solving the problem at hand consists of U-net with 3 different backbones i.e. VGG19, ResNet and InceptionV3. Unet itself is an extended implementation of an encoder-decoder topology of fully convolutional network. The intuition behind Unet is to encode the image through a CNN (encoder-downsampling stage) and then decode it back (decoder-upsampling stage) that gives the segmentation mask. The backbone is the architectural element which modifies the layers in the encoder network and hence modifies the feature extraction and encoding approach area and hence it also determines how the decoder network should be built accordingly that compliments the new modified encoder network. Since each architecture among Vgg, ResNet and Inception excels in different application hence combining all three provides best results in our implementation. Figure 5 shows a general architecture of U-Net implemented with ResNet backbone. Summary of the three models have been given in appendix

All the models are initialized with pretrained weights on ImageNet which not only reduces the training time but improves the learning capability of model in small dataset.

3.4 Model Training

Three different U-net architectures with 3 different backbones are individually trained on the same training dataset. Table 1 shows training parameters used during training of all 3 models.

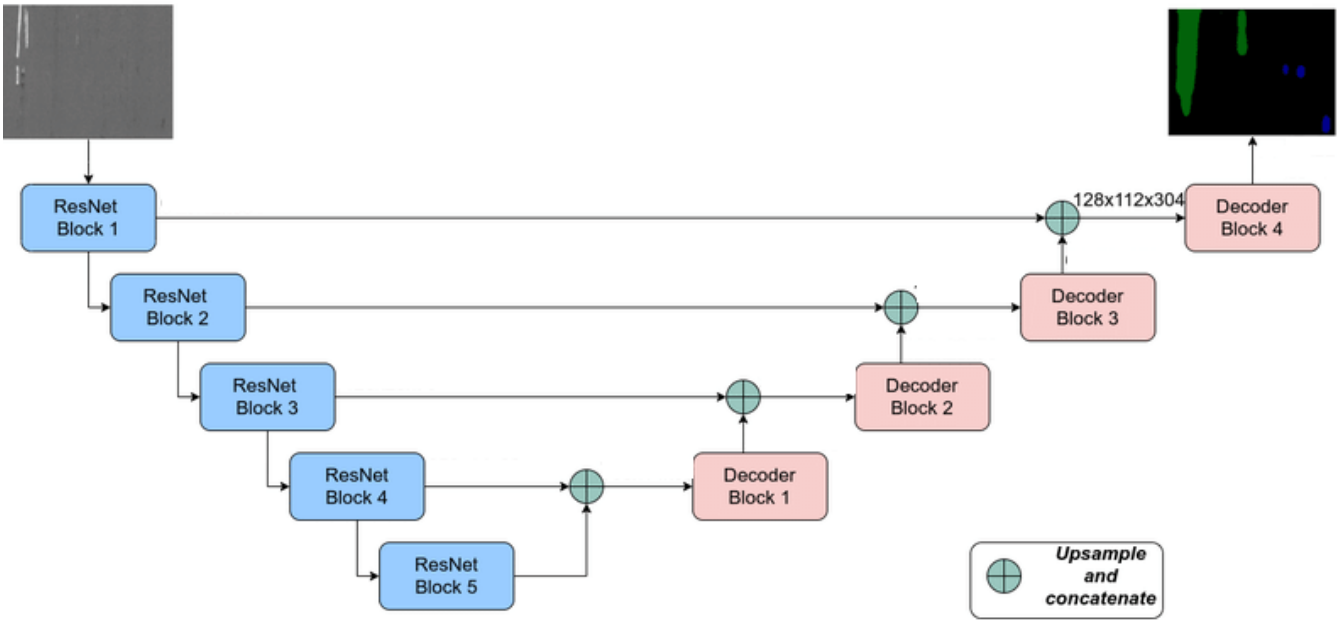

Figure 5: U-Net with ResNet

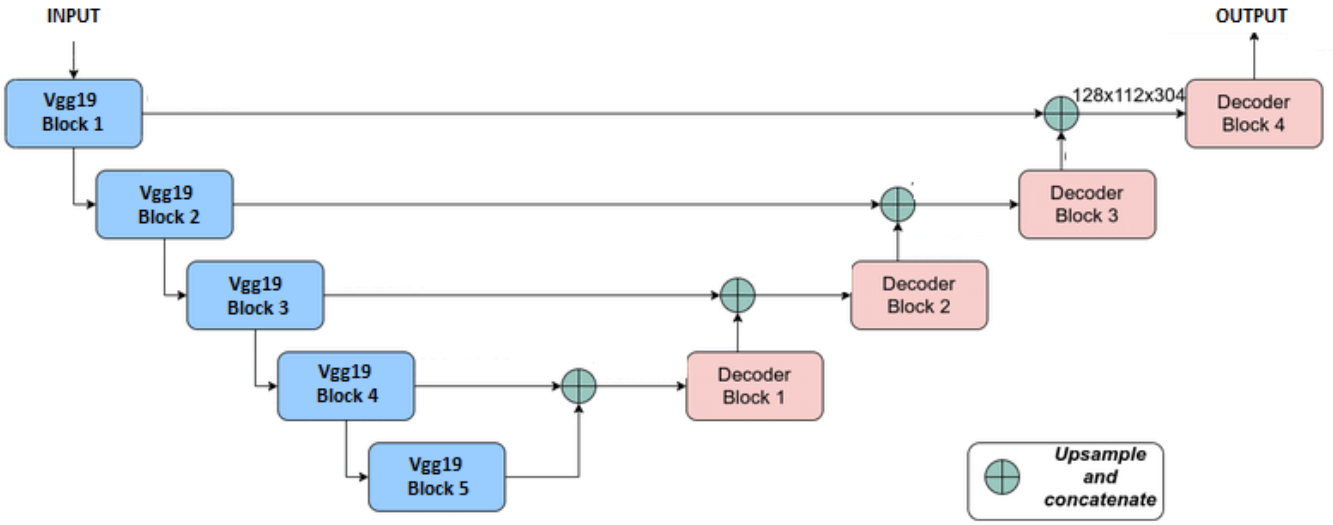

Figure 6: U-Net with VGG19

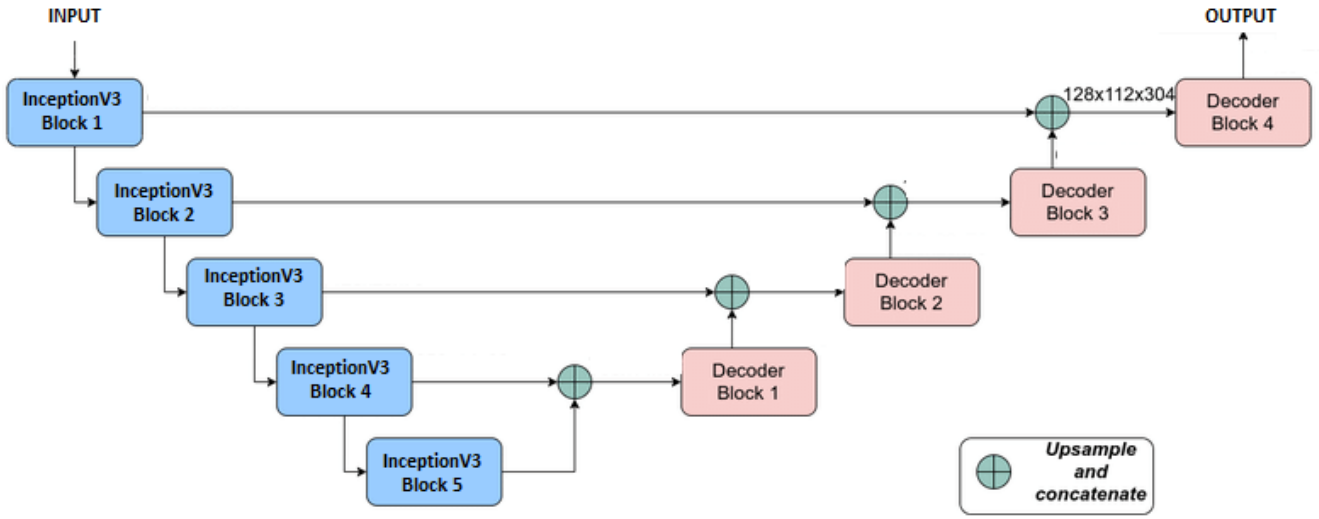

Figure 7: U-Net with InceptionV3

Parameter	**Name**
Loss function	Binary focal dice loss
Metric 1	IOU score(threshold =0.5)
Metric 2	F1 score ((threshold =0.5)
Optimizer	Adam
Batch Size	8
Epochs	100

Table 1: Training Parameters

Figure 8, 9, 10 show individual training progress of all models of U-Net with different backbones. Figure-9 shows training and validation loss of U-Net model with ResNet34 backbone on right and IoU during training on left. It can be seen that during learning progress training loss shows a clear minimizing trend whereas validation loss shows randomly increasing loss because of poor labelling of ground truth data. IoU also tells the same story where training IoU follows the loss trend for training data where as IoU factor for validation data does not improves more than 67

Figure 9 shows same training validation loss for model-2 as observed for model-1 as well as IoU observed on validation data does not improve more than 67% despite

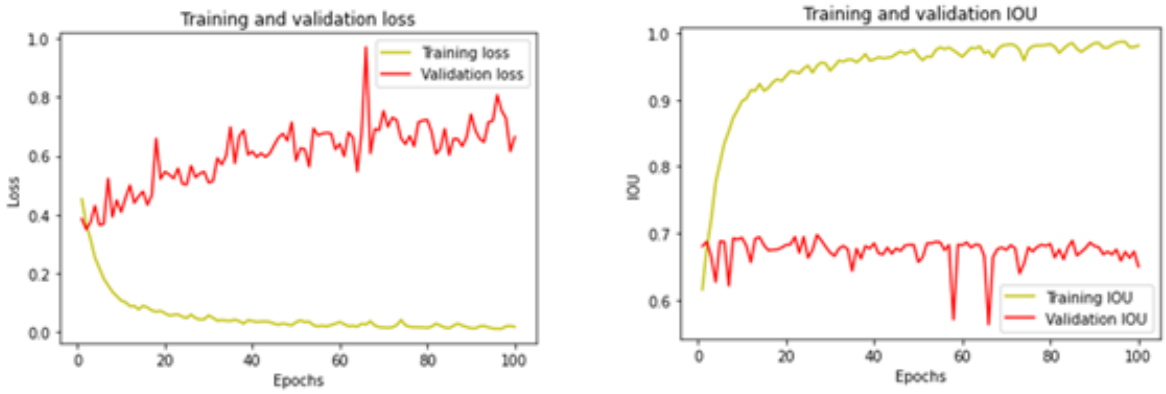

Figure 8: Training progress model 1

training data IoU reached to almost 99%

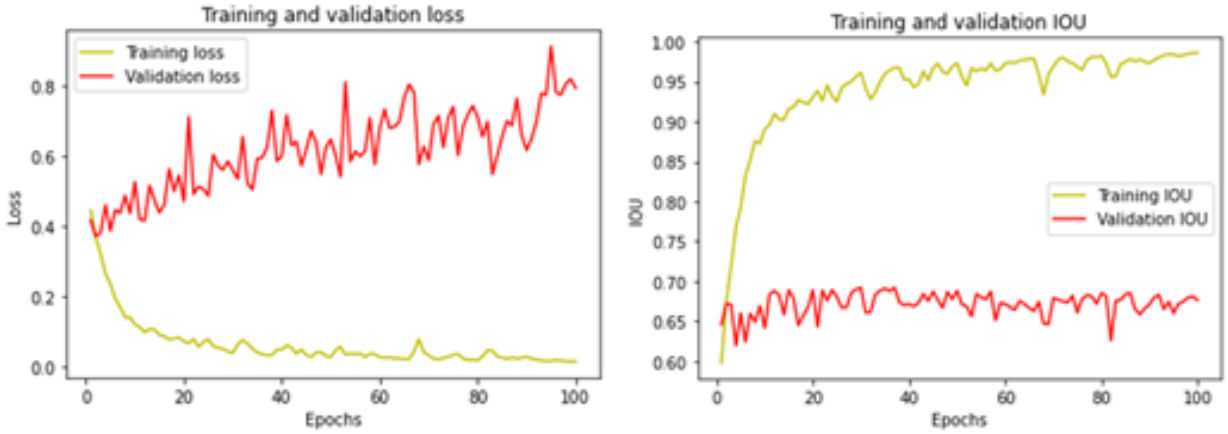

Figure 9: Training progress model 2

Figure 10 shows some different trends for both losses and IoU for training and validation data during training of U-Net using Vgg19 backbone. The validation loss showed decreasing trend in the beginning unlike previous 2 models. IoU on validation data did not show much variations and mostly stayed constant at around 67%.

Ensembling of models for semantic segmentation

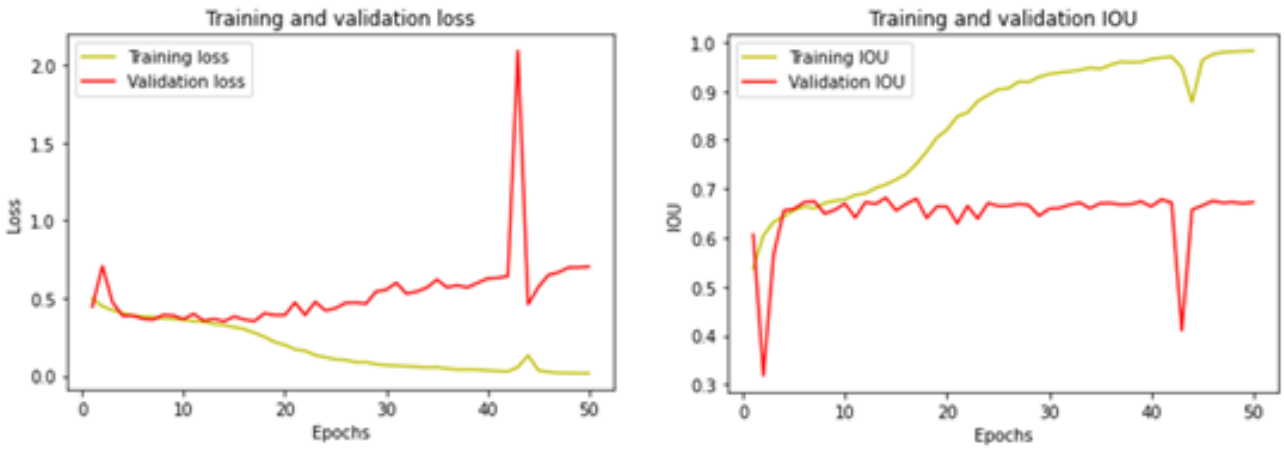

Figure 10: Training progress model 3

All the 3 different variants of U-net are ensembled together to give pixel level classification of each image. Following random combination of weights are selected to get the weighted average of final prediction. w1 =0.3 , w2= 0.5 , w3= 0.2 A best combination of weights for each model is selected that gives best result on prediction on individual prediction of each model. A combination of weighted average of model gives the final prediction, using equation 1

$$P = w1 * p1 + w2 * p2 + w3 * p3$$

Where P= final prediction P1 = prediction by model 1 P2 = prediction by model 2 P3 = prediction by model 3

3.5 Evaluation strategy

The presented approach is evaluated for its accuracy of distinguishing forest regions from non-forest regions in the aerial images. The model tested on already separated test from original dataset consists of 500 images. At test time the implemented model produces for given image a binary image with two regions defined as forest and non-forest images. These predicted binary images are then compared with the provided labels to calculate pixel wise results. IoU factor is used for evaluating the predicted region with provided one. IoU is measured using following mathematical

relation:

$$IOU = \frac{Intersection\ area}{Total\ area}$$

IoU scores can further be converted to mean average precision, but further analysis is not performed due to time constraints.

3.6 Results and Discussion

The ensembling approach presented in above section provided an average pixel classification accuracy of 32%. This low value of accuracy is due to poor labeling of the dataset. Visual inspection of the predicted images has shown better results on average compared to the provided labels and hence despite the low accuracy score the trained model gives acceptable results for real application. IoU score calculated over all three models and ensemble model are as following: Following are the mean IoU obtained for each individual model as well as using the ensembled model.

IOU Score for model1 = 0.6515429

IOU Score for model2 = 0.6777154

IOU Score for model3 = 0.67442536

IOU Score for weighted average ensemble = 0.68797314

Since the provided ground truth data was poorly labelled as can be seen in the (Testing label) in figure 11 - 12hence IoU score did not provided got score despite the fact visual inspection showed extremely impressive prediction of the forest and non-forest regions as shown in Figure 12 and 11

The main rule has been played by the weight initialization using ImageNet trained weights. The models with weights trained on ImageNet has already learned the notion of learning useful object in the real-world images. Training on aerial images further allowed the model to adapt according to the required image regions.

Given below are some example of comparing the mask to the predictions. The figure 13 shows samples that closely match the masks while the figure 14 shows cases which are far from the mask values.

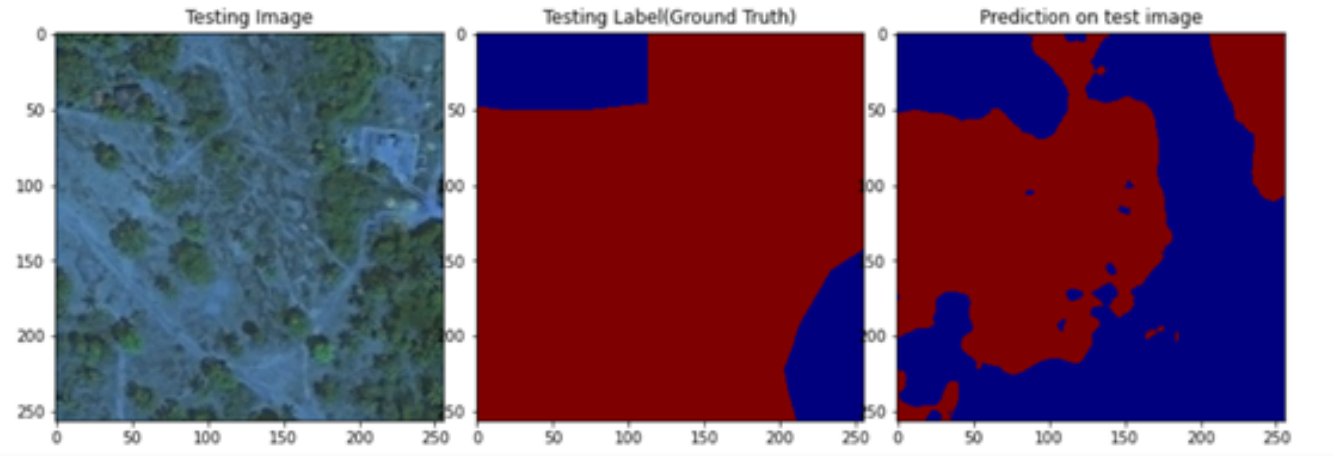

Figure 11: Prediction with Bad IoU scores

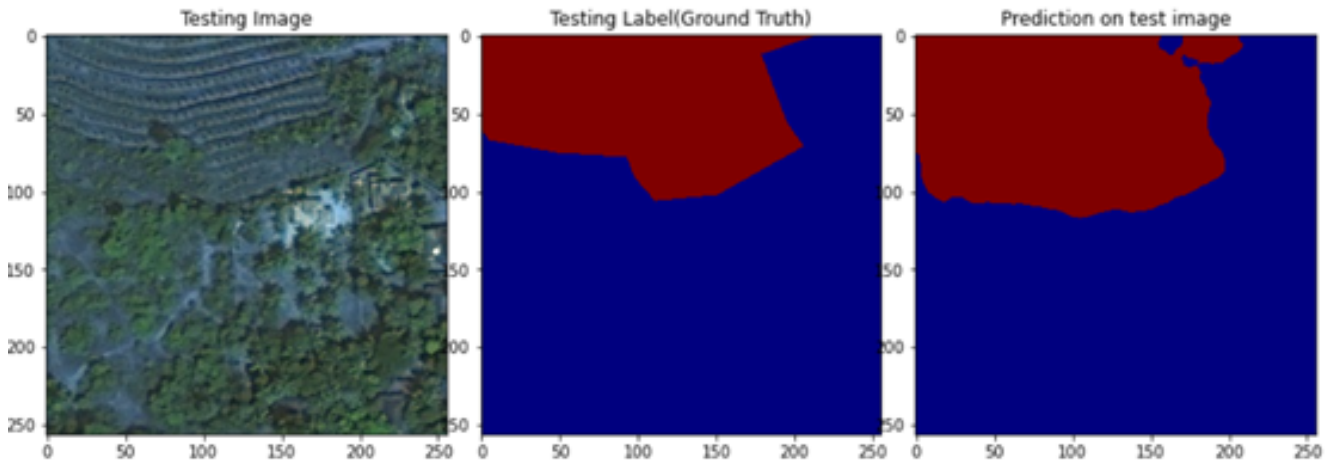

Figure 12: Predictions with Good IoU scores

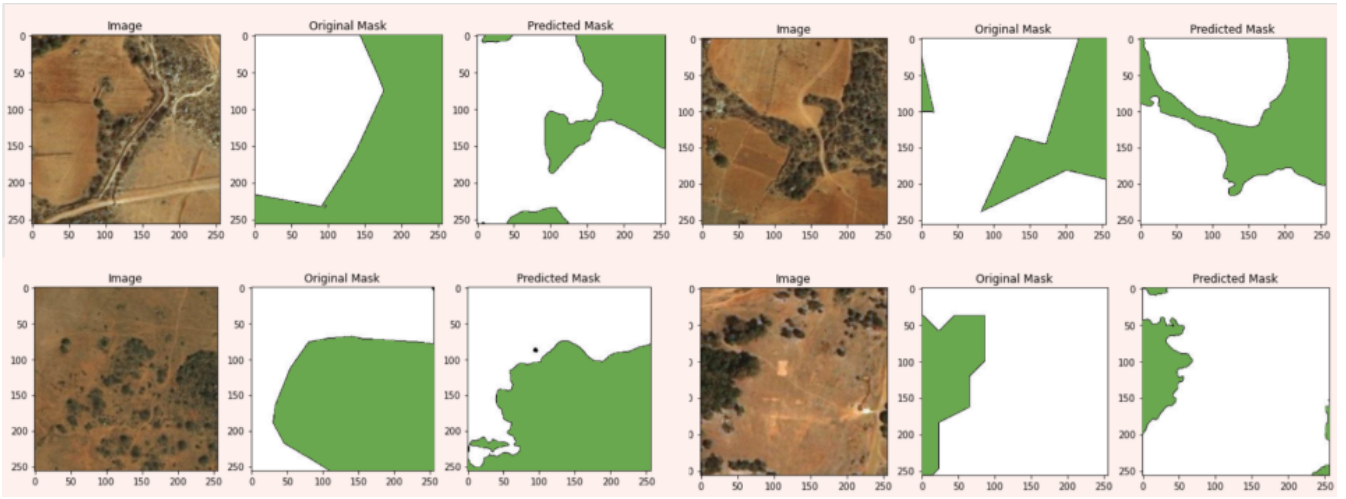

Figure 13: Prediction close to ground truth mask

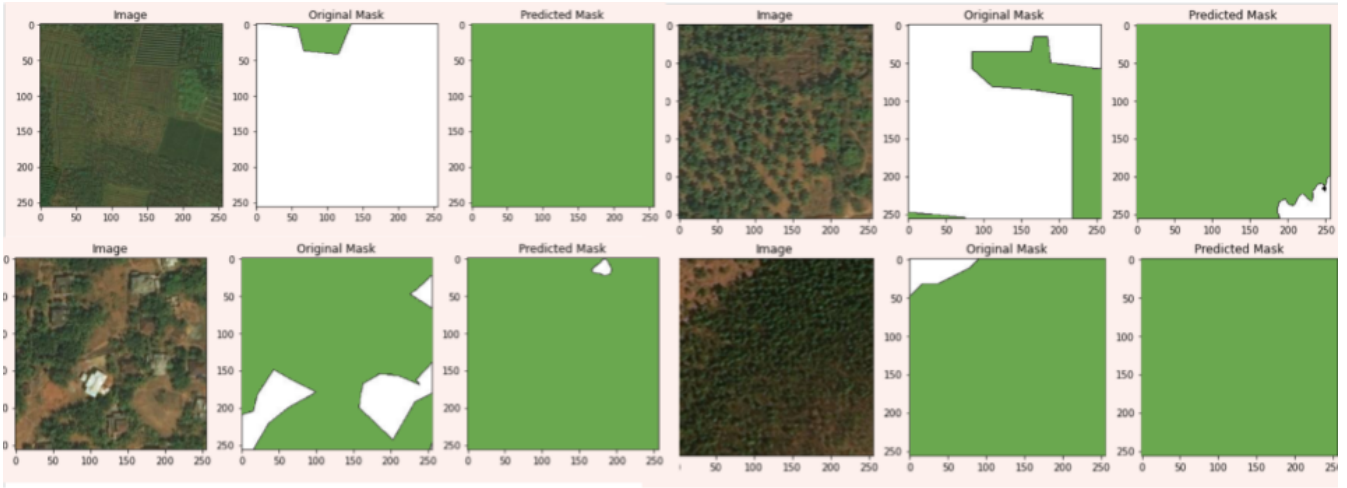

Figure 14: Prediction far from ground truth mask

Yet the most interesting ones are in the figure 15 which shows cases where the predictions seems to be better than the masks themselves. The masks seems to be lazily annotated while the network make better Predictions.

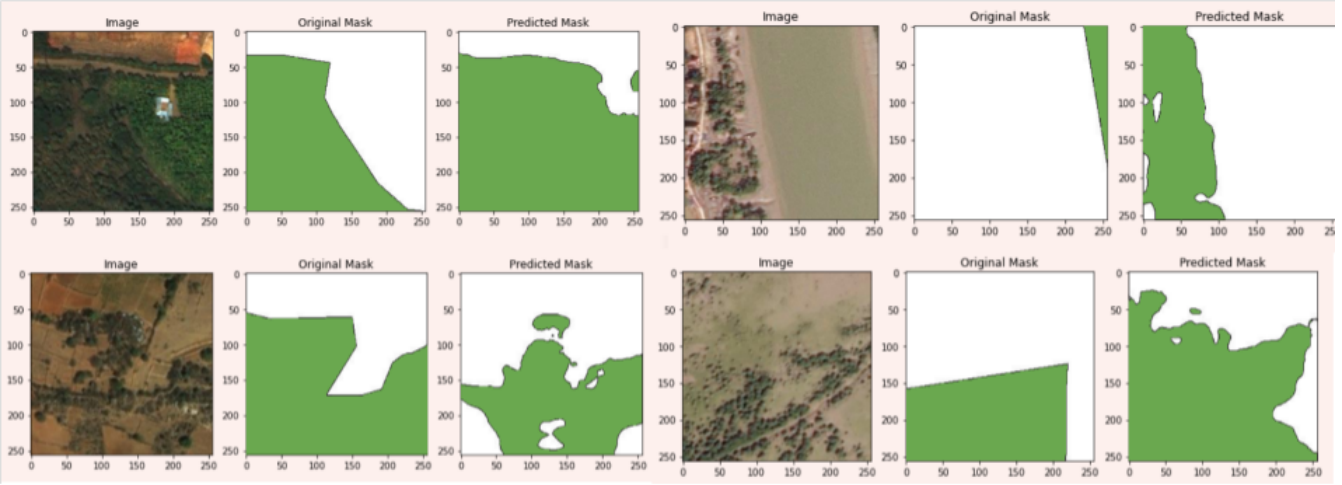

Figure 15: Interesting predictions

References

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[2] "Effects of deforestation - pachamama alliance — pachamama alliance." `https://www.pachamama.org/effects-test`. (Accessed on 02/22/2022).

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4 Appendix

Please see next page

Model: "model_1 (U-Net with res34 backbone "

Layer (type)	Output Shape	Param #	Connected to
data (InputLayer)	[(None, None, None,	0	
bn_data (BatchNormalization)	(None, None, None, 3	9	data[0][0]
zero_padding2d (ZeroPadding2D)	(None, None, None, 3	0	bn_data[0][0]
conv0 (Conv2D)	(None, None, None, 6	9408	zero_padding2d[0][0]
bn0 (BatchNormalization)	(None, None, None, 6	256	conv0[0][0]
relu0 (Activation)	(None, None, None, 6	0	bn0[0][0]
zero_padding2d_1 (ZeroPadding2D	(None, None, None, 6	0	relu0[0][0]
pooling0 (MaxPooling2D)	(None, None, None, 6	0	zero_padding2d_1[0][0]
stage1_unit1_bn1 (BatchNormaliz	(None, None, None, 6	256	pooling0[0][0]
stage1_unit1_relu1 (Activation)	(None, None, None, 6	0	stage1_unit1_bn1[0][0]
zero_padding2d_2 (ZeroPadding2D	(None, None, None, 6	0	stage1_unit1_relu1[0][0]
stage1_unit1_conv1 (Conv2D)	(None, None, None, 6	36864	zero_padding2d_2[0][0]
stage1_unit1_bn2 (BatchNormaliz	(None, None, None, 6	256	stage1_unit1_conv1[0][0]
stage1_unit1_relu2 (Activation)	(None, None, None, 6	0	stage1_unit1_bn2[0][0]
zero_padding2d_3 (ZeroPadding2D	(None, None, None, 6	0	stage1_unit1_relu2[0][0]
stage1_unit1_conv2 (Conv2D)	(None, None, None, 6	36864	zero_padding2d_3[0][0]
stage1_unit1_sc (Conv2D)	(None, None, None, 6	4096	stage1_unit1_relu1[0][0]
add (Add)	(None, None, None, 6	0	stage1_unit1_conv2[0][0] stage1_unit1_sc[0][0]
stage1_unit2_bn1 (BatchNormaliz	(None, None, None, 6	256	add[0][0]
stage1_unit2_relu1 (Activation)	(None, None, None, 6	0	stage1_unit2_bn1[0][0]
zero_padding2d_4 (ZeroPadding2D	(None, None, None, 6	0	stage1_unit2_relu1[0][0]
stage1_unit2_conv1 (Conv2D)	(None, None, None, 6	36864	zero_padding2d_4[0][0]
stage1_unit2_bn2 (BatchNormaliz	(None, None, None, 6	256	stage1_unit2_conv1[0][0]
stage1_unit2_relu2 (Activation)	(None, None, None, 6	0	stage1_unit2_bn2[0][0]
zero_padding2d_5 (ZeroPadding2D	(None, None, None, 6	0	stage1_unit2_relu2[0][0]
stage1_unit2_conv2 (Conv2D)	(None, None, None, 6	36864	zero_padding2d_5[0][0]
add_1 (Add)	(None, None, None, 6	0	stage1_unit2_conv2[0][0] add[0][0]
stage1_unit3_bn1 (BatchNormaliz	(None, None, None, 6	256	add_1[0][0]
stage1_unit3_relu1 (Activation)	(None, None, None, 6	0	stage1_unit3_bn1[0][0]
zero_padding2d_6 (ZeroPadding2D	(None, None, None, 6	0	stage1_unit3_relu1[0][0]
stage1_unit3_conv1 (Conv2D)	(None, None, None, 6	36864	zero_padding2d_6[0][0]
stage1_unit3_bn2 (BatchNormaliz	(None, None, None, 6	256	stage1_unit3_conv1[0][0]

stage1_unit3_relu2 (Activation) (None, None, None, 6 0 stage1_unit3_bn2[0][0]

zero_padding2d_7 (ZeroPadding2D (None, None, None, 6 0 stage1_unit3_relu2[0][0]

stage1_unit3_conv2 (Conv2D) (None, None, None, 6 36864 zero_padding2d_7[0][0]

add_2 (Add) (None, None, None, 6 0 stage1_unit3_conv2[0][0]
add_1[0][0]

stage2_unit1_bn1 (BatchNormaliz (None, None, None, 6 256 add_2[0][0]

stage2_unit1_relu1 (Activation) (None, None, None, 6 0 stage2_unit1_bn1[0][0]

zero_padding2d_8 (ZeroPadding2D (None, None, None, 6 0 stage2_unit1_relu1[0][0]

stage2_unit1_conv1 (Conv2D) (None, None, None, 1 73728 zero_padding2d_8[0][0]

stage2_unit1_bn2 (BatchNormaliz (None, None, None, 1 512 stage2_unit1_conv1[0][0]

stage2_unit1_relu2 (Activation) (None, None, None, 1 0 stage2_unit1_bn2[0][0]

zero_padding2d_9 (ZeroPadding2D (None, None, None, 1 0 stage2_unit1_relu2[0][0]

stage2_unit1_conv2 (Conv2D) (None, None, None, 1 147456 zero_padding2d_9[0][0]

stage2_unit1_sc (Conv2D) (None, None, None, 1 8192 stage2_unit1_relu1[0][0]

add_3 (Add) (None, None, None, 1 0 stage2_unit1_conv2[0][0]
stage2_unit1_sc[0][0]

stage2_unit2_bn1 (BatchNormaliz (None, None, None, 1 512 add_3[0][0]

stage2_unit2_relu1 (Activation) (None, None, None, 1 0 stage2_unit2_bn1[0][0]

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stage2_unit2_bn2 (BatchNormaliz (None, None, None, 1 512 stage2_unit2_conv1[0][0]

stage2_unit2_relu2 (Activation) (None, None, None, 1 0 stage2_unit2_bn2[0][0]

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stage2_unit2_conv2 (Conv2D) (None, None, None, 1 147456 zero_padding2d_11[0][0]

add_4 (Add) (None, None, None, 1 0 stage2_unit2_conv2[0][0]
add_3[0][0]

stage2_unit3_bn1 (BatchNormaliz (None, None, None, 1 512 add_4[0][0]

stage2_unit3_relu1 (Activation) (None, None, None, 1 0 stage2_unit3_bn1[0][0]

zero_padding2d_12 (ZeroPadding2 (None, None, None, 1 0 stage2_unit3_relu1[0][0]

stage2_unit3_conv1 (Conv2D) (None, None, None, 1 147456 zero_padding2d_12[0][0]

stage2_unit3_bn2 (BatchNormaliz (None, None, None, 1 512 stage2_unit3_conv1[0][0]

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zero_padding2d_13 (ZeroPadding2 (None, None, None, 1 0 stage2_unit3_relu2[0][0]

stage2_unit3_conv2 (Conv2D) (None, None, None, 1 147456 zero_padding2d_13[0][0]

add_5 (Add) (None, None, None, 1 0 stage2_unit3_conv2[0][0]
add_4[0][0]

stage2_unit4_bn1 (BatchNormaliz (None, None, None, 1 512 add_5[0][0]

stage2_unit4_relu1 (Activation) (None, None, None, 1 0 stage2_unit4_bn1[0][0]

zero_padding2d_14 (ZeroPadding2	(None, None, None, 1	0	stage2_unit4_relu1[0][0]
stage2_unit4_conv1 (Conv2D)	(None, None, None, 1	147456	zero_padding2d_14[0][0]
stage2_unit4_bn2 (BatchNormaliz	(None, None, None, 1	512	stage2_unit4_conv1[0][0]
stage2_unit4_relu2 (Activation)	(None, None, None, 1	0	stage2_unit4_bn2[0][0]
zero_padding2d_15 (ZeroPadding2	(None, None, None, 1	0	stage2_unit4_relu2[0][0]
stage2_unit4_conv2 (Conv2D)	(None, None, None, 1	147456	zero_padding2d_15[0][0]
add_6 (Add)	(None, None, None, 1	0	stage2_unit4_conv2[0][0] add_5[0][0]
stage3_unit1_bn1 (BatchNormaliz	(None, None, None, 1	512	add_6[0][0]
stage3_unit1_relu1 (Activation)	(None, None, None, 1	0	stage3_unit1_bn1[0][0]
zero_padding2d_16 (ZeroPadding2	(None, None, None, 1	0	stage3_unit1_relu1[0][0]
stage3_unit1_conv1 (Conv2D)	(None, None, None, 2	294912	zero_padding2d_16[0][0]
stage3_unit1_bn2 (BatchNormaliz	(None, None, None, 2	1024	stage3_unit1_conv1[0][0]
stage3_unit1_relu2 (Activation)	(None, None, None, 2	0	stage3_unit1_bn2[0][0]
zero_padding2d_17 (ZeroPadding2	(None, None, None, 2	0	stage3_unit1_relu2[0][0]
stage3_unit1_conv2 (Conv2D)	(None, None, None, 2	589824	zero_padding2d_17[0][0]
stage3_unit1_sc (Conv2D)	(None, None, None, 2	32768	stage3_unit1_relu1[0][0]
add_7 (Add)	(None, None, None, 2	0	stage3_unit1_conv2[0][0] stage3_unit1_sc[0][0]
stage3_unit2_bn1 (BatchNormaliz	(None, None, None, 2	1024	add_7[0][0]
stage3_unit2_relu1 (Activation)	(None, None, None, 2	0	stage3_unit2_bn1[0][0]
zero_padding2d_18 (ZeroPadding2	(None, None, None, 2	0	stage3_unit2_relu1[0][0]
stage3_unit2_conv1 (Conv2D)	(None, None, None, 2	589824	zero_padding2d_18[0][0]
stage3_unit2_bn2 (BatchNormaliz	(None, None, None, 2	1024	stage3_unit2_conv1[0][0]
stage3_unit2_relu2 (Activation)	(None, None, None, 2	0	stage3_unit2_bn2[0][0]
zero_padding2d_19 (ZeroPadding2	(None, None, None, 2	0	stage3_unit2_relu2[0][0]
stage3_unit2_conv2 (Conv2D)	(None, None, None, 2	589824	zero_padding2d_19[0][0]
add_8 (Add)	(None, None, None, 2	0	stage3_unit2_conv2[0][0] add_7[0][0]
stage3_unit3_bn1 (BatchNormaliz	(None, None, None, 2	1024	add_8[0][0]
stage3_unit3_relu1 (Activation)	(None, None, None, 2	0	stage3_unit3_bn1[0][0]
zero_padding2d_20 (ZeroPadding2	(None, None, None, 2	0	stage3_unit3_relu1[0][0]
stage3_unit3_conv1 (Conv2D)	(None, None, None, 2	589824	zero_padding2d_20[0][0]
stage3_unit3_bn2 (BatchNormaliz	(None, None, None, 2	1024	stage3_unit3_conv1[0][0]
stage3_unit3_relu2 (Activation)	(None, None, None, 2	0	stage3_unit3_bn2[0][0]
zero_padding2d_21 (ZeroPadding2	(None, None, None, 2	0	stage3_unit3_relu2[0][0]
stage3_unit3_conv2 (Conv2D)	(None, None, None, 2	589824	zero_padding2d_21[0][0]

add_9 (Add)	(None, None, None, 2	0	stage3_unit3_conv2[0][0] add_8[0][0]	
stage3_unit4_bn1 (BatchNormaliz	(None, None, None, 2	1024	add_9[0][0]	
stage3_unit4_relu1 (Activation)	(None, None, None, 2	0	stage3_unit4_bn1[0][0]	
zero_padding2d_22 (ZeroPadding2	(None, None, None, 2	0	stage3_unit4_relu1[0][0]	
stage3_unit4_conv1 (Conv2D)	(None, None, None, 2	589824	zero_padding2d_22[0][0]	
stage3_unit4_bn2 (BatchNormaliz	(None, None, None, 2	1024	stage3_unit4_conv1[0][0]	
stage3_unit4_relu2 (Activation)	(None, None, None, 2	0	stage3_unit4_bn2[0][0]	
zero_padding2d_23 (ZeroPadding2	(None, None, None, 2	0	stage3_unit4_relu2[0][0]	
stage3_unit4_conv2 (Conv2D)	(None, None, None, 2	589824	zero_padding2d_23[0][0]	
add_10 (Add)	(None, None, None, 2	0	stage3_unit4_conv2[0][0] add_9[0][0]	
stage3_unit5_bn1 (BatchNormaliz	(None, None, None, 2	1024	add_10[0][0]	
stage3_unit5_relu1 (Activation)	(None, None, None, 2	0	stage3_unit5_bn1[0][0]	
zero_padding2d_24 (ZeroPadding2	(None, None, None, 2	0	stage3_unit5_relu1[0][0]	
stage3_unit5_conv1 (Conv2D)	(None, None, None, 2	589824	zero_padding2d_24[0][0]	
stage3_unit5_bn2 (BatchNormaliz	(None, None, None, 2	1024	stage3_unit5_conv1[0][0]	
stage3_unit5_relu2 (Activation)	(None, None, None, 2	0	stage3_unit5_bn2[0][0]	
zero_padding2d_25 (ZeroPadding2	(None, None, None, 2	0	stage3_unit5_relu2[0][0]	
stage3_unit5_conv2 (Conv2D)	(None, None, None, 2	589824	zero_padding2d_25[0][0]	
add_11 (Add)	(None, None, None, 2	0	stage3_unit5_conv2[0][0] add_10[0][0]	
stage3_unit6_bn1 (BatchNormaliz	(None, None, None, 2	1024	add_11[0][0]	
stage3_unit6_relu1 (Activation)	(None, None, None, 2	0	stage3_unit6_bn1[0][0]	
zero_padding2d_26 (ZeroPadding2	(None, None, None, 2	0	stage3_unit6_relu1[0][0]	
stage3_unit6_conv1 (Conv2D)	(None, None, None, 2	589824	zero_padding2d_26[0][0]	
stage3_unit6_bn2 (BatchNormaliz	(None, None, None, 2	1024	stage3_unit6_conv1[0][0]	
stage3_unit6_relu2 (Activation)	(None, None, None, 2	0	stage3_unit6_bn2[0][0]	
zero_padding2d_27 (ZeroPadding2	(None, None, None, 2	0	stage3_unit6_relu2[0][0]	
stage3_unit6_conv2 (Conv2D)	(None, None, None, 2	589824	zero_padding2d_27[0][0]	
add_12 (Add)	(None, None, None, 2	0	stage3_unit6_conv2[0][0] add_11[0][0]	
stage4_unit1_bn1 (BatchNormaliz	(None, None, None, 2	1024	add_12[0][0]	
stage4_unit1_relu1 (Activation)	(None, None, None, 2	0	stage4_unit1_bn1[0][0]	
zero_padding2d_28 (ZeroPadding2	(None, None, None, 2	0	stage4_unit1_relu1[0][0]	
stage4_unit1_conv1 (Conv2D)	(None, None, None, 5	1179648	zero_padding2d_28[0][0]	
stage4_unit1_bn2 (BatchNormaliz	(None, None, None, 5	2048	stage4_unit1_conv1[0][0]	
stage4_unit1_relu2 (Activation)	(None, None, None, 5	0	stage4_unit1_bn2[0][0]	

zero_padding2d_29 (ZeroPadding2 (None, None, None, 5 0 stage4_unit1_relu2[0][0]

---

stage4_unit1_conv2 (Conv2D) (None, None, None, 5 2359296 zero_padding2d_29[0][0]

---

stage4_unit1_sc (Conv2D) (None, None, None, 5 131072 stage4_unit1_relu1[0][0]

---

add_13 (Add) (None, None, None, 5 0 stage4_unit1_conv2[0][0]
stage4_unit1_sc[0][0]

---

stage4_unit2_bn1 (BatchNormaliz (None, None, None, 5 2048 add_13[0][0]

---

stage4_unit2_relu1 (Activation) (None, None, None, 5 0 stage4_unit2_bn1[0][0]

---

zero_padding2d_30 (ZeroPadding2 (None, None, None, 5 0 stage4_unit2_relu1[0][0]

---

stage4_unit2_conv1 (Conv2D) (None, None, None, 5 2359296 zero_padding2d_30[0][0]

---

stage4_unit2_bn2 (BatchNormaliz (None, None, None, 5 2048 stage4_unit2_conv1[0][0]

---

stage4_unit2_relu2 (Activation) (None, None, None, 5 0 stage4_unit2_bn2[0][0]

---

zero_padding2d_31 (ZeroPadding2 (None, None, None, 5 0 stage4_unit2_relu2[0][0]

---

stage4_unit2_conv2 (Conv2D) (None, None, None, 5 2359296 zero_padding2d_31[0][0]

---

add_14 (Add) (None, None, None, 5 0 stage4_unit2_conv2[0][0]
add_13[0][0]

---

stage4_unit3_bn1 (BatchNormaliz (None, None, None, 5 2048 add_14[0][0]

---

stage4_unit3_relu1 (Activation) (None, None, None, 5 0 stage4_unit3_bn1[0][0]

---

zero_padding2d_32 (ZeroPadding2 (None, None, None, 5 0 stage4_unit3_relu1[0][0]

---

stage4_unit3_conv1 (Conv2D) (None, None, None, 5 2359296 zero_padding2d_32[0][0]

---

stage4_unit3_bn2 (BatchNormaliz (None, None, None, 5 2048 stage4_unit3_conv1[0][0]

---

stage4_unit3_relu2 (Activation) (None, None, None, 5 0 stage4_unit3_bn2[0][0]

---

zero_padding2d_33 (ZeroPadding2 (None, None, None, 5 0 stage4_unit3_relu2[0][0]

---

stage4_unit3_conv2 (Conv2D) (None, None, None, 5 2359296 zero_padding2d_33[0][0]

---

add_15 (Add) (None, None, None, 5 0 stage4_unit3_conv2[0][0]
add_14[0][0]

---

bn1 (BatchNormalization) (None, None, None, 5 2048 add_15[0][0]

---

relu1 (Activation) (None, None, None, 5 0 bn1[0][0]

---

decoder_stage0_upsampling (UpSa (None, None, None, 5 0 relu1[0][0]

---

decoder_stage0_concat (Concaten (None, None, None, 7 0 decoder_stage0_upsampling[0][0]
stage4_unit1_relu1[0][0]

---

decoder_stage0a_conv (Conv2D) (None, None, None, 2 1769472 decoder_stage0_concat[0][0]

---

decoder_stage0a_bn (BatchNormal (None, None, None, 2 1024 decoder_stage0a_conv[0][0]

---

decoder_stage0a_relu (Activatio (None, None, None, 2 0 decoder_stage0a_bn[0][0]

---

decoder_stage0b_conv (Conv2D) (None, None, None, 2 589824 decoder_stage0a_relu[0][0]

---

decoder_stage0b_bn (BatchNormal (None, None, None, 2 1024 decoder_stage0b_conv[0][0]

---

decoder_stage0b_relu (Activatio (None, None, None, 2 0 decoder_stage0b_bn[0][0]

---

decoder_stage1_upsampling (UpSa (None, None, None, 2 0 decoder_stage0b_relu[0][0]

---

decoder_stage1_concat (Concaten (None, None, None, 3 0 decoder_stage1_upsampling[0][0]
stage3_unit1_relu1[0][0]

decoder_stage1a_conv (Conv2D) (None, None, None, 1 442368 decoder_stage1_concat[0][0]

decoder_stage1a_bn (BatchNormal (None, None, None, 1 512 decoder_stage1a_conv[0][0]

decoder_stage1a_relu (Activatio (None, None, None, 1 0 decoder_stage1a_bn[0][0]

decoder_stage1b_conv (Conv2D) (None, None, None, 1 147456 decoder_stage1a_relu[0][0]

decoder_stage1b_bn (BatchNormal (None, None, None, 1 512 decoder_stage1b_conv[0][0]

decoder_stage1b_relu (Activatio (None, None, None, 1 0 decoder_stage1b_bn[0][0]

decoder_stage2_upsampling (UpSa (None, None, None, 1 0 decoder_stage1b_relu[0][0]

decoder_stage2_concat (Concaten (None, None, None, 1 0 decoder_stage2_upsampling[0][0]
stage2_unit1_relu1[0][0]

decoder_stage2a_conv (Conv2D) (None, None, None, 6 110592 decoder_stage2_concat[0][0]

decoder_stage2a_bn (BatchNormal (None, None, None, 6 256 decoder_stage2a_conv[0][0]

decoder_stage2a_relu (Activatio (None, None, None, 6 0 decoder_stage2a_bn[0][0]

decoder_stage2b_conv (Conv2D) (None, None, None, 6 36864 decoder_stage2a_relu[0][0]

decoder_stage2b_bn (BatchNormal (None, None, None, 6 256 decoder_stage2b_conv[0][0]

decoder_stage2b_relu (Activatio (None, None, None, 6 0 decoder_stage2b_bn[0][0]

decoder_stage3_upsampling (UpSa (None, None, None, 6 0 decoder_stage2b_relu[0][0]

decoder_stage3_concat (Concaten (None, None, None, 1 0 decoder_stage3_upsampling[0][0]
relu0[0][0]

decoder_stage3a_conv (Conv2D) (None, None, None, 3 36864 decoder_stage3_concat[0][0]

decoder_stage3a_bn (BatchNormal (None, None, None, 3 128 decoder_stage3a_conv[0][0]

decoder_stage3a_relu (Activatio (None, None, None, 3 0 decoder_stage3a_bn[0][0]

decoder_stage3b_conv (Conv2D) (None, None, None, 3 9216 decoder_stage3a_relu[0][0]

decoder_stage3b_bn (BatchNormal (None, None, None, 3 128 decoder_stage3b_conv[0][0]

decoder_stage3b_relu (Activatio (None, None, None, 3 0 decoder_stage3b_bn[0][0]

decoder_stage4_upsampling (UpSa (None, None, None, 3 0 decoder_stage3b_relu[0][0]

decoder_stage4a_conv (Conv2D) (None, None, None, 1 4608 decoder_stage4_upsampling[0][0]

decoder_stage4a_bn (BatchNormal (None, None, None, 1 64 decoder_stage4a_conv[0][0]

decoder_stage4a_relu (Activatio (None, None, None, 1 0 decoder_stage4a_bn[0][0]

decoder_stage4b_conv (Conv2D) (None, None, None, 1 2304 decoder_stage4a_relu[0][0]

decoder_stage4b_bn (BatchNormal (None, None, None, 1 64 decoder_stage4b_conv[0][0]

decoder_stage4b_relu (Activatio (None, None, None, 1 0 decoder_stage4b_bn[0][0]

final_conv (Conv2D) (None, None, None, 2 290 decoder_stage4b_relu[0][0]

sigmoid (Activation) (None, None, None, 2 0 final_conv[0][0]

==========

Total params: 24,456,299
Trainable params: 24,438,949
Non-trainable params: 17,350

Model: "model-2 (U-Net with InceptionV3 backbone)"

Layer (type)	Output Shape	Param #	Connected to
input_1 (InputLayer)	[(None, None, None,	0	
conv2d (Conv2D)	(None, None, None, 3	864	input_1[0][0]
batch_normalization (BatchNorma	(None, None, None, 3	96	conv2d[0][0]
activation (Activation)	(None, None, None, 3	0	batch_normalization[0][0]
conv2d_1 (Conv2D)	(None, None, None, 3	9216	activation[0][0]
batch_normalization_1 (BatchNor	(None, None, None, 3	96	conv2d_1[0][0]
activation_1 (Activation)	(None, None, None, 3	0	batch_normalization_1[0][0]
conv2d_2 (Conv2D)	(None, None, None, 6	18432	activation_1[0][0]
batch_normalization_2 (BatchNor	(None, None, None, 6	192	conv2d_2[0][0]
activation_2 (Activation)	(None, None, None, 6	0	batch_normalization_2[0][0]
max_pooling2d (MaxPooling2D)	(None, None, None, 6	0	activation_2[0][0]
conv2d_3 (Conv2D)	(None, None, None, 8	5120	max_pooling2d[0][0]
batch_normalization_3 (BatchNor	(None, None, None, 8	240	conv2d_3[0][0]
activation_3 (Activation)	(None, None, None, 8	0	batch_normalization_3[0][0]
conv2d_4 (Conv2D)	(None, None, None, 1	138240	activation_3[0][0]
batch_normalization_4 (BatchNor	(None, None, None, 1	576	conv2d_4[0][0]
activation_4 (Activation)	(None, None, None, 1	0	batch_normalization_4[0][0]
max_pooling2d_1 (MaxPooling2D)	(None, None, None, 1	0	activation_4[0][0]
conv2d_8 (Conv2D)	(None, None, None, 6	12288	max_pooling2d_1[0][0]
batch_normalization_8 (BatchNor	(None, None, None, 6	192	conv2d_8[0][0]
activation_8 (Activation)	(None, None, None, 6	0	batch_normalization_8[0][0]
conv2d_6 (Conv2D)	(None, None, None, 4	9216	max_pooling2d_1[0][0]
conv2d_9 (Conv2D)	(None, None, None, 9	55296	activation_8[0][0]
batch_normalization_6 (BatchNor	(None, None, None, 4	144	conv2d_6[0][0]
batch_normalization_9 (BatchNor	(None, None, None, 9	288	conv2d_9[0][0]
activation_6 (Activation)	(None, None, None, 4	0	batch_normalization_6[0][0]
activation_9 (Activation)	(None, None, None, 9	0	batch_normalization_9[0][0]
average_pooling2d (AveragePooli	(None, None, None, 1	0	max_pooling2d_1[0][0]
conv2d_5 (Conv2D)	(None, None, None, 6	12288	max_pooling2d_1[0][0]
conv2d_7 (Conv2D)	(None, None, None, 6	76800	activation_6[0][0]
conv2d_10 (Conv2D)	(None, None, None, 9	82944	activation_9[0][0]
conv2d_11 (Conv2D)	(None, None, None, 3	6144	average_pooling2d[0][0]
batch_normalization_5 (BatchNor	(None, None, None, 6	192	conv2d_5[0][0]
batch_normalization_7 (BatchNor	(None, None, None, 6	192	conv2d_7[0][0]

batch_normalization_10 (BatchNo (None, None, None, 9 288 conv2d_10[0][0]

batch_normalization_11 (BatchNo (None, None, None, 3 96 conv2d_11[0][0]

activation_5 (Activation) (None, None, None, 6 0 batch_normalization_5[0][0]

activation_7 (Activation) (None, None, None, 6 0 batch_normalization_7[0][0]

activation_10 (Activation) (None, None, None, 9 0 batch_normalization_10[0][0]

activation_11 (Activation) (None, None, None, 3 0 batch_normalization_11[0][0]

mixed0 (Concatenate) (None, None, None, 2 0 activation_5[0][0]
activation_7[0][0]
activation_10[0][0]
activation_11[0][0]

conv2d_15 (Conv2D) (None, None, None, 6 16384 mixed0[0][0]

batch_normalization_15 (BatchNo (None, None, None, 6 192 conv2d_15[0][0]

activation_15 (Activation) (None, None, None, 6 0 batch_normalization_15[0][0]

conv2d_13 (Conv2D) (None, None, None, 4 12288 mixed0[0][0]

conv2d_16 (Conv2D) (None, None, None, 9 55296 activation_15[0][0]

batch_normalization_13 (BatchNo (None, None, None, 4 144 conv2d_13[0][0]

batch_normalization_16 (BatchNo (None, None, None, 9 288 conv2d_16[0][0]

activation_13 (Activation) (None, None, None, 4 0 batch_normalization_13[0][0]

activation_16 (Activation) (None, None, None, 9 0 batch_normalization_16[0][0]

average_pooling2d_1 (AveragePoo (None, None, None, 2 0 mixed0[0][0]

conv2d_12 (Conv2D) (None, None, None, 6 16384 mixed0[0][0]

conv2d_14 (Conv2D) (None, None, None, 6 76800 activation_13[0][0]

conv2d_17 (Conv2D) (None, None, None, 9 82944 activation_16[0][0]

conv2d_18 (Conv2D) (None, None, None, 6 16384 average_pooling2d_1[0][0]

batch_normalization_12 (BatchNo (None, None, None, 6 192 conv2d_12[0][0]

batch_normalization_14 (BatchNo (None, None, None, 6 192 conv2d_14[0][0]

batch_normalization_17 (BatchNo (None, None, None, 9 288 conv2d_17[0][0]

batch_normalization_18 (BatchNo (None, None, None, 6 192 conv2d_18[0][0]

activation_12 (Activation) (None, None, None, 6 0 batch_normalization_12[0][0]

activation_14 (Activation) (None, None, None, 6 0 batch_normalization_14[0][0]

activation_17 (Activation) (None, None, None, 9 0 batch_normalization_17[0][0]

activation_18 (Activation) (None, None, None, 6 0 batch_normalization_18[0][0]

mixed1 (Concatenate) (None, None, None, 2 0 activation_12[0][0]
activation_14[0][0]
activation_17[0][0]
activation_18[0][0]

conv2d_22 (Conv2D) (None, None, None, 6 18432 mixed1[0][0]

batch_normalization_22 (BatchNo (None, None, None, 6 192 conv2d_22[0][0]

activation_22 (Activation) (None, None, None, 6 0 batch_normalization_22[0][0]

conv2d_20 (Conv2D) (None, None, None, 4 13824 mixed1[0][0]

conv2d_23 (Conv2D) (None, None, None, 9 55296 activation_22[0][0]

batch_normalization_20 (BatchNo (None, None, None, 4 144 conv2d_20[0][0]

batch_normalization_23 (BatchNo (None, None, None, 9 288 conv2d_23[0][0]

activation_20 (Activation) (None, None, None, 4 0 batch_normalization_20[0][0]

activation_23 (Activation) (None, None, None, 9 0 batch_normalization_23[0][0]

average_pooling2d_2 (AveragePoo (None, None, None, 2 0 mixed1[0][0]

conv2d_19 (Conv2D) (None, None, None, 6 18432 mixed1[0][0]

conv2d_21 (Conv2D) (None, None, None, 6 76800 activation_20[0][0]

conv2d_24 (Conv2D) (None, None, None, 9 82944 activation_23[0][0]

conv2d_25 (Conv2D) (None, None, None, 6 18432 average_pooling2d_2[0][0]

batch_normalization_19 (BatchNo (None, None, None, 6 192 conv2d_19[0][0]

batch_normalization_21 (BatchNo (None, None, None, 6 192 conv2d_21[0][0]

batch_normalization_24 (BatchNo (None, None, None, 9 288 conv2d_24[0][0]

batch_normalization_25 (BatchNo (None, None, None, 6 192 conv2d_25[0][0]

activation_19 (Activation) (None, None, None, 6 0 batch_normalization_19[0][0]

activation_21 (Activation) (None, None, None, 6 0 batch_normalization_21[0][0]

activation_24 (Activation) (None, None, None, 9 0 batch_normalization_24[0][0]

activation_25 (Activation) (None, None, None, 6 0 batch_normalization_25[0][0]

mixed2 (Concatenate) (None, None, None, 2 0 activation_19[0][0]
activation_21[0][0]
activation_24[0][0]
activation_25[0][0]

conv2d_27 (Conv2D) (None, None, None, 6 18432 mixed2[0][0]

batch_normalization_27 (BatchNo (None, None, None, 6 192 conv2d_27[0][0]

activation_27 (Activation) (None, None, None, 6 0 batch_normalization_27[0][0]

conv2d_28 (Conv2D) (None, None, None, 9 55296 activation_27[0][0]

batch_normalization_28 (BatchNo (None, None, None, 9 288 conv2d_28[0][0]

activation_28 (Activation) (None, None, None, 9 0 batch_normalization_28[0][0]

conv2d_26 (Conv2D) (None, None, None, 3 995328 mixed2[0][0]

conv2d_29 (Conv2D) (None, None, None, 9 82944 activation_28[0][0]

batch_normalization_26 (BatchNo (None, None, None, 3 1152 conv2d_26[0][0]

batch_normalization_29 (BatchNo (None, None, None, 9 288 conv2d_29[0][0]

activation_26 (Activation) (None, None, None, 3 0 batch_normalization_26[0][0]

activation_29 (Activation) (None, None, None, 9 0 batch_normalization_29[0][0]

max_pooling2d_2 (MaxPooling2D) (None, None, None, 2 0 mixed2[0][0]

mixed3 (Concatenate) (None, None, None, 7 0 activation_26[0][0]
activation_29[0][0]
max_pooling2d_2[0][0]

conv2d_34 (Conv2D)	(None, None, None, 1	98304	mixed3[0][0]
batch_normalization_34 (BatchNo	(None, None, None, 1	384	conv2d_34[0][0]
activation_34 (Activation)	(None, None, None, 1	0	batch_normalization_34[0][0]
conv2d_35 (Conv2D)	(None, None, None, 1	114688	activation_34[0][0]
batch_normalization_35 (BatchNo	(None, None, None, 1	384	conv2d_35[0][0]
activation_35 (Activation)	(None, None, None, 1	0	batch_normalization_35[0][0]
conv2d_31 (Conv2D)	(None, None, None, 1	98304	mixed3[0][0]
conv2d_36 (Conv2D)	(None, None, None, 1	114688	activation_35[0][0]
batch_normalization_31 (BatchNo	(None, None, None, 1	384	conv2d_31[0][0]
batch_normalization_36 (BatchNo	(None, None, None, 1	384	conv2d_36[0][0]
activation_31 (Activation)	(None, None, None, 1	0	batch_normalization_31[0][0]
activation_36 (Activation)	(None, None, None, 1	0	batch_normalization_36[0][0]
conv2d_32 (Conv2D)	(None, None, None, 1	114688	activation_31[0][0]
conv2d_37 (Conv2D)	(None, None, None, 1	114688	activation_36[0][0]
batch_normalization_32 (BatchNo	(None, None, None, 1	384	conv2d_32[0][0]
batch_normalization_37 (BatchNo	(None, None, None, 1	384	conv2d_37[0][0]
activation_32 (Activation)	(None, None, None, 1	0	batch_normalization_32[0][0]
activation_37 (Activation)	(None, None, None, 1	0	batch_normalization_37[0][0]
average_pooling2d_3 (AveragePoo	(None, None, None, 7	0	mixed3[0][0]
conv2d_30 (Conv2D)	(None, None, None, 1	147456	mixed3[0][0]
conv2d_33 (Conv2D)	(None, None, None, 1	172032	activation_32[0][0]
conv2d_38 (Conv2D)	(None, None, None, 1	172032	activation_37[0][0]
conv2d_39 (Conv2D)	(None, None, None, 1	147456	average_pooling2d_3[0][0]
batch_normalization_30 (BatchNo	(None, None, None, 1	576	conv2d_30[0][0]
batch_normalization_33 (BatchNo	(None, None, None, 1	576	conv2d_33[0][0]
batch_normalization_38 (BatchNo	(None, None, None, 1	576	conv2d_38[0][0]
batch_normalization_39 (BatchNo	(None, None, None, 1	576	conv2d_39[0][0]
activation_30 (Activation)	(None, None, None, 1	0	batch_normalization_30[0][0]
activation_33 (Activation)	(None, None, None, 1	0	batch_normalization_33[0][0]
activation_38 (Activation)	(None, None, None, 1	0	batch_normalization_38[0][0]
activation_39 (Activation)	(None, None, None, 1	0	batch_normalization_39[0][0]
mixed4 (Concatenate)	(None, None, None, 7	0	activation_30[0][0] activation_33[0][0] activation_38[0][0] activation_39[0][0]
conv2d_44 (Conv2D)	(None, None, None, 1	122880	mixed4[0][0]
batch_normalization_44 (BatchNo	(None, None, None, 1	480	conv2d_44[0][0]

activation_44 (Activation) (None, None, None, 1 0 batch_normalization_44[0][0]

conv2d_45 (Conv2D) (None, None, None, 1 179200 activation_44[0][0]

batch_normalization_45 (BatchNo (None, None, None, 1 480 conv2d_45[0][0]

activation_45 (Activation) (None, None, None, 1 0 batch_normalization_45[0][0]

conv2d_41 (Conv2D) (None, None, None, 1 122880 mixed4[0][0]

conv2d_46 (Conv2D) (None, None, None, 1 179200 activation_45[0][0]

batch_normalization_41 (BatchNo (None, None, None, 1 480 conv2d_41[0][0]

batch_normalization_46 (BatchNo (None, None, None, 1 480 conv2d_46[0][0]

activation_41 (Activation) (None, None, None, 1 0 batch_normalization_41[0][0]

activation_46 (Activation) (None, None, None, 1 0 batch_normalization_46[0][0]

conv2d_42 (Conv2D) (None, None, None, 1 179200 activation_41[0][0]

conv2d_47 (Conv2D) (None, None, None, 1 179200 activation_46[0][0]

batch_normalization_42 (BatchNo (None, None, None, 1 480 conv2d_42[0][0]

batch_normalization_47 (BatchNo (None, None, None, 1 480 conv2d_47[0][0]

activation_42 (Activation) (None, None, None, 1 0 batch_normalization_42[0][0]

activation_47 (Activation) (None, None, None, 1 0 batch_normalization_47[0][0]

average_pooling2d_4 (AveragePoo (None, None, None, 7 0 mixed4[0][0]

conv2d_40 (Conv2D) (None, None, None, 1 147456 mixed4[0][0]

conv2d_43 (Conv2D) (None, None, None, 1 215040 activation_42[0][0]

conv2d_48 (Conv2D) (None, None, None, 1 215040 activation_47[0][0]

conv2d_49 (Conv2D) (None, None, None, 1 147456 average_pooling2d_4[0][0]

batch_normalization_40 (BatchNo (None, None, None, 1 576 conv2d_40[0][0]

batch_normalization_43 (BatchNo (None, None, None, 1 576 conv2d_43[0][0]

batch_normalization_48 (BatchNo (None, None, None, 1 576 conv2d_48[0][0]

batch_normalization_49 (BatchNo (None, None, None, 1 576 conv2d_49[0][0]

activation_40 (Activation) (None, None, None, 1 0 batch_normalization_40[0][0]

activation_43 (Activation) (None, None, None, 1 0 batch_normalization_43[0][0]

activation_48 (Activation) (None, None, None, 1 0 batch_normalization_48[0][0]

activation_49 (Activation) (None, None, None, 1 0 batch_normalization_49[0][0]

mixed5 (Concatenate) (None, None, None, 7 0 activation_40[0][0]
activation_43[0][0]
activation_48[0][0]
activation_49[0][0]

conv2d_54 (Conv2D) (None, None, None, 1 122880 mixed5[0][0]

batch_normalization_54 (BatchNo (None, None, None, 1 480 conv2d_54[0][0]

activation_54 (Activation) (None, None, None, 1 0 batch_normalization_54[0][0]

conv2d_55 (Conv2D) (None, None, None, 1 179200 activation_54[0][0]

batch_normalization_55 (BatchNo (None, None, None, 1 480 conv2d_55[0][0]

activation_55 (Activation)	(None, None, None, 1	0	batch_normalization_55[0][0]
conv2d_51 (Conv2D)	(None, None, None, 1	122880	mixed5[0][0]
conv2d_56 (Conv2D)	(None, None, None, 1	179200	activation_55[0][0]
batch_normalization_51 (BatchNo	(None, None, None, 1	480	conv2d_51[0][0]
batch_normalization_56 (BatchNo	(None, None, None, 1	480	conv2d_56[0][0]
activation_51 (Activation)	(None, None, None, 1	0	batch_normalization_51[0][0]
activation_56 (Activation)	(None, None, None, 1	0	batch_normalization_56[0][0]
conv2d_52 (Conv2D)	(None, None, None, 1	179200	activation_51[0][0]
conv2d_57 (Conv2D)	(None, None, None, 1	179200	activation_56[0][0]
batch_normalization_52 (BatchNo	(None, None, None, 1	480	conv2d_52[0][0]
batch_normalization_57 (BatchNo	(None, None, None, 1	480	conv2d_57[0][0]
activation_52 (Activation)	(None, None, None, 1	0	batch_normalization_52[0][0]
activation_57 (Activation)	(None, None, None, 1	0	batch_normalization_57[0][0]
average_pooling2d_5 (AveragePoo	(None, None, None, 7	0	mixed5[0][0]
conv2d_50 (Conv2D)	(None, None, None, 1	147456	mixed5[0][0]
conv2d_53 (Conv2D)	(None, None, None, 1	215040	activation_52[0][0]
conv2d_58 (Conv2D)	(None, None, None, 1	215040	activation_57[0][0]
conv2d_59 (Conv2D)	(None, None, None, 1	147456	average_pooling2d_5[0][0]
batch_normalization_50 (BatchNo	(None, None, None, 1	576	conv2d_50[0][0]
batch_normalization_53 (BatchNo	(None, None, None, 1	576	conv2d_53[0][0]
batch_normalization_58 (BatchNo	(None, None, None, 1	576	conv2d_58[0][0]
batch_normalization_59 (BatchNo	(None, None, None, 1	576	conv2d_59[0][0]
activation_50 (Activation)	(None, None, None, 1	0	batch_normalization_50[0][0]
activation_53 (Activation)	(None, None, None, 1	0	batch_normalization_53[0][0]
activation_58 (Activation)	(None, None, None, 1	0	batch_normalization_58[0][0]
activation_59 (Activation)	(None, None, None, 1	0	batch_normalization_59[0][0]
mixed6 (Concatenate)	(None, None, None, 7	0	activation_50[0][0] activation_53[0][0] activation_58[0][0] activation_59[0][0]
conv2d_64 (Conv2D)	(None, None, None, 1	147456	mixed6[0][0]
batch_normalization_64 (BatchNo	(None, None, None, 1	576	conv2d_64[0][0]
activation_64 (Activation)	(None, None, None, 1	0	batch_normalization_64[0][0]
conv2d_65 (Conv2D)	(None, None, None, 1	258048	activation_64[0][0]
batch_normalization_65 (BatchNo	(None, None, None, 1	576	conv2d_65[0][0]
activation_65 (Activation)	(None, None, None, 1	0	batch_normalization_65[0][0]
conv2d_61 (Conv2D)	(None, None, None, 1	147456	mixed6[0][0]

conv2d_66 (Conv2D) (None, None, None, 1 258048 activation_65[0][0]

batch_normalization_61 (BatchNo (None, None, None, 1 576 conv2d_61[0][0]

batch_normalization_66 (BatchNo (None, None, None, 1 576 conv2d_66[0][0]

activation_61 (Activation) (None, None, None, 1 0 batch_normalization_61[0][0]

activation_66 (Activation) (None, None, None, 1 0 batch_normalization_66[0][0]

conv2d_62 (Conv2D) (None, None, None, 1 258048 activation_61[0][0]

conv2d_67 (Conv2D) (None, None, None, 1 258048 activation_66[0][0]

batch_normalization_62 (BatchNo (None, None, None, 1 576 conv2d_62[0][0]

batch_normalization_67 (BatchNo (None, None, None, 1 576 conv2d_67[0][0]

activation_62 (Activation) (None, None, None, 1 0 batch_normalization_62[0][0]

activation_67 (Activation) (None, None, None, 1 0 batch_normalization_67[0][0]

average_pooling2d_6 (AveragePoo (None, None, None, 7 0 mixed6[0][0]

conv2d_60 (Conv2D) (None, None, None, 1 147456 mixed6[0][0]

conv2d_63 (Conv2D) (None, None, None, 1 258048 activation_62[0][0]

conv2d_68 (Conv2D) (None, None, None, 1 258048 activation_67[0][0]

conv2d_69 (Conv2D) (None, None, None, 1 147456 average_pooling2d_6[0][0]

batch_normalization_60 (BatchNo (None, None, None, 1 576 conv2d_60[0][0]

batch_normalization_63 (BatchNo (None, None, None, 1 576 conv2d_63[0][0]

batch_normalization_68 (BatchNo (None, None, None, 1 576 conv2d_68[0][0]

batch_normalization_69 (BatchNo (None, None, None, 1 576 conv2d_69[0][0]

activation_60 (Activation) (None, None, None, 1 0 batch_normalization_60[0][0]

activation_63 (Activation) (None, None, None, 1 0 batch_normalization_63[0][0]

activation_68 (Activation) (None, None, None, 1 0 batch_normalization_68[0][0]

activation_69 (Activation) (None, None, None, 1 0 batch_normalization_69[0][0]

mixed7 (Concatenate) (None, None, None, 7 0 activation_60[0][0]
activation_63[0][0]
activation_68[0][0]
activation_69[0][0]

conv2d_72 (Conv2D) (None, None, None, 1 147456 mixed7[0][0]

batch_normalization_72 (BatchNo (None, None, None, 1 576 conv2d_72[0][0]

activation_72 (Activation) (None, None, None, 1 0 batch_normalization_72[0][0]

conv2d_73 (Conv2D) (None, None, None, 1 258048 activation_72[0][0]

batch_normalization_73 (BatchNo (None, None, None, 1 576 conv2d_73[0][0]

activation_73 (Activation) (None, None, None, 1 0 batch_normalization_73[0][0]

conv2d_70 (Conv2D) (None, None, None, 1 147456 mixed7[0][0]

conv2d_74 (Conv2D) (None, None, None, 1 258048 activation_73[0][0]

batch_normalization_70 (BatchNo (None, None, None, 1 576 conv2d_70[0][0]

batch_normalization_74 (BatchNo (None, None, None, 1 576 conv2d_74[0][0]

activation_70 (Activation)	(None, None, None, 1	0	batch_normalization_70[0][0]
activation_74 (Activation)	(None, None, None, 1	0	batch_normalization_74[0][0]
conv2d_71 (Conv2D)	(None, None, None, 3	552960	activation_70[0][0]
conv2d_75 (Conv2D)	(None, None, None, 1	331776	activation_74[0][0]
batch_normalization_71 (BatchNo	(None, None, None, 3	960	conv2d_71[0][0]
batch_normalization_75 (BatchNo	(None, None, None, 1	576	conv2d_75[0][0]
activation_71 (Activation)	(None, None, None, 3	0	batch_normalization_71[0][0]
activation_75 (Activation)	(None, None, None, 1	0	batch_normalization_75[0][0]
max_pooling2d_3 (MaxPooling2D)	(None, None, None, 7	0	mixed7[0][0]
mixed8 (Concatenate)	(None, None, None, 1	0	activation_71[0][0] activation_75[0][0] max_pooling2d_3[0][0]
conv2d_80 (Conv2D)	(None, None, None, 4	573440	mixed8[0][0]
batch_normalization_80 (BatchNo	(None, None, None, 4	1344	conv2d_80[0][0]
activation_80 (Activation)	(None, None, None, 4	0	batch_normalization_80[0][0]
conv2d_77 (Conv2D)	(None, None, None, 3	491520	mixed8[0][0]
conv2d_81 (Conv2D)	(None, None, None, 3	1548288	activation_80[0][0]
batch_normalization_77 (BatchNo	(None, None, None, 3	1152	conv2d_77[0][0]
batch_normalization_81 (BatchNo	(None, None, None, 3	1152	conv2d_81[0][0]
activation_77 (Activation)	(None, None, None, 3	0	batch_normalization_77[0][0]
activation_81 (Activation)	(None, None, None, 3	0	batch_normalization_81[0][0]
conv2d_78 (Conv2D)	(None, None, None, 3	442368	activation_77[0][0]
conv2d_79 (Conv2D)	(None, None, None, 3	442368	activation_77[0][0]
conv2d_82 (Conv2D)	(None, None, None, 3	442368	activation_81[0][0]
conv2d_83 (Conv2D)	(None, None, None, 3	442368	activation_81[0][0]
average_pooling2d_7 (AveragePoo	(None, None, None, 1	0	mixed8[0][0]
conv2d_76 (Conv2D)	(None, None, None, 3	409600	mixed8[0][0]
batch_normalization_78 (BatchNo	(None, None, None, 3	1152	conv2d_78[0][0]
batch_normalization_79 (BatchNo	(None, None, None, 3	1152	conv2d_79[0][0]
batch_normalization_82 (BatchNo	(None, None, None, 3	1152	conv2d_82[0][0]
batch_normalization_83 (BatchNo	(None, None, None, 3	1152	conv2d_83[0][0]
conv2d_84 (Conv2D)	(None, None, None, 1	245760	average_pooling2d_7[0][0]
batch_normalization_76 (BatchNo	(None, None, None, 3	960	conv2d_76[0][0]
activation_78 (Activation)	(None, None, None, 3	0	batch_normalization_78[0][0]
activation_79 (Activation)	(None, None, None, 3	0	batch_normalization_79[0][0]
activation_82 (Activation)	(None, None, None, 3	0	batch_normalization_82[0][0]
activation_83 (Activation)	(None, None, None, 3	0	batch_normalization_83[0][0]

batch_normalization_84 (BatchNo	(None, None, None,	1 576	conv2d_84[0][0]
activation_76 (Activation)	(None, None, None,	3 0	batch_normalization_76[0][0]
mixed9_0 (Concatenate)	(None, None, None,	7 0	activation_78[0][0] activation_79[0][0]
concatenate (Concatenate)	(None, None, None,	7 0	activation_82[0][0] activation_83[0][0]
activation_84 (Activation)	(None, None, None,	1 0	batch_normalization_84[0][0]
mixed9 (Concatenate)	(None, None, None,	2 0	activation_76[0][0] mixed9_0[0][0] concatenate[0][0] activation_84[0][0]
conv2d_89 (Conv2D)	(None, None, None,	4 917504	mixed9[0][0]
batch_normalization_89 (BatchNo	(None, None, None,	4 1344	conv2d_89[0][0]
activation_89 (Activation)	(None, None, None,	4 0	batch_normalization_89[0][0]
conv2d_86 (Conv2D)	(None, None, None,	3 786432	mixed9[0][0]
conv2d_90 (Conv2D)	(None, None, None,	3 1548288	activation_89[0][0]
batch_normalization_86 (BatchNo	(None, None, None,	3 1152	conv2d_86[0][0]
batch_normalization_90 (BatchNo	(None, None, None,	3 1152	conv2d_90[0][0]
activation_86 (Activation)	(None, None, None,	3 0	batch_normalization_86[0][0]
activation_90 (Activation)	(None, None, None,	3 0	batch_normalization_90[0][0]
conv2d_87 (Conv2D)	(None, None, None,	3 442368	activation_86[0][0]
conv2d_88 (Conv2D)	(None, None, None,	3 442368	activation_86[0][0]
conv2d_91 (Conv2D)	(None, None, None,	3 442368	activation_90[0][0]
conv2d_92 (Conv2D)	(None, None, None,	3 442368	activation_90[0][0]
average_pooling2d_8 (AveragePoo	(None, None, None,	2 0	mixed9[0][0]
conv2d_85 (Conv2D)	(None, None, None,	3 655360	mixed9[0][0]
batch_normalization_87 (BatchNo	(None, None, None,	3 1152	conv2d_87[0][0]
batch_normalization_88 (BatchNo	(None, None, None,	3 1152	conv2d_88[0][0]
batch_normalization_91 (BatchNo	(None, None, None,	3 1152	conv2d_91[0][0]
batch_normalization_92 (BatchNo	(None, None, None,	3 1152	conv2d_92[0][0]
conv2d_93 (Conv2D)	(None, None, None,	1 393216	average_pooling2d_8[0][0]
batch_normalization_85 (BatchNo	(None, None, None,	3 960	conv2d_85[0][0]
activation_87 (Activation)	(None, None, None,	3 0	batch_normalization_87[0][0]
activation_88 (Activation)	(None, None, None,	3 0	batch_normalization_88[0][0]
activation_91 (Activation)	(None, None, None,	3 0	batch_normalization_91[0][0]
activation_92 (Activation)	(None, None, None,	3 0	batch_normalization_92[0][0]
batch_normalization_93 (BatchNo	(None, None, None,	1 576	conv2d_93[0][0]
activation_85 (Activation)	(None, None, None,	3 0	batch_normalization_85[0][0]

mixed9_1 (Concatenate) (None, None, None, 7 0 activation_87[0][0]
activation_88[0][0]

concatenate_1 (Concatenate) (None, None, None, 7 0 activation_91[0][0]
activation_92[0][0]

activation_93 (Activation) (None, None, None, 1 0 batch_normalization_93[0][0]

mixed10 (Concatenate) (None, None, None, 2 0 activation_85[0][0]
mixed9_1[0][0]
concatenate_1[0][0]
activation_93[0][0]

decoder_stage0_upsampling (UpSa (None, None, None, 2 0 mixed10[0][0]

decoder_stage0_concat (Concaten (None, None, None, 2 0 decoder_stage0_upsampling[0][0]
mixed7[0][0]

decoder_stage0a_conv (Conv2D) (None, None, None, 2 6488064 decoder_stage0_concat[0][0]

decoder_stage0a_bn (BatchNormal (None, None, None, 2 1024 decoder_stage0a_conv[0][0]

decoder_stage0a_relu (Activatio (None, None, None, 2 0 decoder_stage0a_bn[0][0]

decoder_stage0b_conv (Conv2D) (None, None, None, 2 589824 decoder_stage0a_relu[0][0]

decoder_stage0b_bn (BatchNormal (None, None, None, 2 1024 decoder_stage0b_conv[0][0]

decoder_stage0b_relu (Activatio (None, None, None, 2 0 decoder_stage0b_bn[0][0]

decoder_stage1_upsampling (UpSa (None, None, None, 2 0 decoder_stage0b_relu[0][0]

decoder_stage1_concat (Concaten (None, None, None, 5 0 decoder_stage1_upsampling[0][0]
mixed2[0][0]

decoder_stage1a_conv (Conv2D) (None, None, None, 1 626688 decoder_stage1_concat[0][0]

decoder_stage1a_bn (BatchNormal (None, None, None, 1 512 decoder_stage1a_conv[0][0]

decoder_stage1a_relu (Activatio (None, None, None, 1 0 decoder_stage1a_bn[0][0]

decoder_stage1b_conv (Conv2D) (None, None, None, 1 147456 decoder_stage1a_relu[0][0]

decoder_stage1b_bn (BatchNormal (None, None, None, 1 512 decoder_stage1b_conv[0][0]

decoder_stage1b_relu (Activatio (None, None, None, 1 0 decoder_stage1b_bn[0][0]

decoder_stage2_upsampling (UpSa (None, None, None, 1 0 decoder_stage1b_relu[0][0]

decoder_stage2_concat (Concaten (None, None, None, 3 0 decoder_stage2_upsampling[0][0]
activation_4[0][0]

decoder_stage2a_conv (Conv2D) (None, None, None, 6 184320 decoder_stage2_concat[0][0]

decoder_stage2a_bn (BatchNormal (None, None, None, 6 256 decoder_stage2a_conv[0][0]

decoder_stage2a_relu (Activatio (None, None, None, 6 0 decoder_stage2a_bn[0][0]

decoder_stage2b_conv (Conv2D) (None, None, None, 6 36864 decoder_stage2a_relu[0][0]

decoder_stage2b_bn (BatchNormal (None, None, None, 6 256 decoder_stage2b_conv[0][0]

decoder_stage2b_relu (Activatio (None, None, None, 6 0 decoder_stage2b_bn[0][0]

decoder_stage3_upsampling (UpSa (None, None, None, 6 0 decoder_stage2b_relu[0][0]

decoder_stage3_concat (Concaten (None, None, None, 1 0 decoder_stage3_upsampling[0][0]
activation_2[0][0]

decoder_stage3a_conv (Conv2D) (None, None, None, 3 36864 decoder_stage3_concat[0][0]

decoder_stage3a_bn (BatchNormal (None, None, None, 3 128 decoder_stage3a_conv[0][0]

decoder_stage3a_relu (Activatio	(None, None, None, 3	0	decoder_stage3a_bn[0][0]
decoder_stage3b_conv (Conv2D)	(None, None, None, 3	9216	decoder_stage3a_relu[0][0]
decoder_stage3b_bn (BatchNormal	(None, None, None, 3	128	decoder_stage3b_conv[0][0]
decoder_stage3b_relu (Activatio	(None, None, None, 3	0	decoder_stage3b_bn[0][0]
decoder_stage4_upsampling (UpSa	(None, None, None, 3	0	decoder_stage3b_relu[0][0]
decoder_stage4a_conv (Conv2D)	(None, None, None, 1	4608	decoder_stage4_upsampling[0][0]
decoder_stage4a_bn (BatchNormal	(None, None, None, 1	64	decoder_stage4a_conv[0][0]
decoder_stage4a_relu (Activatio	(None, None, None, 1	0	decoder_stage4a_bn[0][0]
decoder_stage4b_conv (Conv2D)	(None, None, None, 1	2304	decoder_stage4a_relu[0][0]
decoder_stage4b_bn (BatchNormal	(None, None, None, 1	64	decoder_stage4b_conv[0][0]
decoder_stage4b_relu (Activatio	(None, None, None, 1	0	decoder_stage4b_bn[0][0]
final_conv (Conv2D)	(None, None, None, 2	290	decoder_stage4b_relu[0][0]
sigmoid (Activation)	(None, None, None, 2	0	final_conv[0][0]

Total params: 29,933,250
Trainable params: 29,896,834
Non-trainable params: 36,416

Model: "model-3 (U-Net with Vgg19 backbone)"

Layer (type)	Output Shape	Param #	Connected to
input_1 (InputLayer)	[(None, None, None,	0	
block1_conv1 (Conv2D)	(None, None, None, 6	1792	input_1[0][0]
block1_conv2 (Conv2D)	(None, None, None, 6	36928	block1_conv1[0][0]
block1_pool (MaxPooling2D)	(None, None, None, 6	0	block1_conv2[0][0]
block2_conv1 (Conv2D)	(None, None, None, 1	73856	block1_pool[0][0]
block2_conv2 (Conv2D)	(None, None, None, 1	147584	block2_conv1[0][0]
block2_pool (MaxPooling2D)	(None, None, None, 1	0	block2_conv2[0][0]
block3_conv1 (Conv2D)	(None, None, None, 2	295168	block2_pool[0][0]
block3_conv2 (Conv2D)	(None, None, None, 2	590080	block3_conv1[0][0]
block3_conv3 (Conv2D)	(None, None, None, 2	590080	block3_conv2[0][0]
block3_pool (MaxPooling2D)	(None, None, None, 2	0	block3_conv3[0][0]
block4_conv1 (Conv2D)	(None, None, None, 5	1180160	block3_pool[0][0]
block4_conv2 (Conv2D)	(None, None, None, 5	2359808	block4_conv1[0][0]
block4_conv3 (Conv2D)	(None, None, None, 5	2359808	block4_conv2[0][0]
block4_pool (MaxPooling2D)	(None, None, None, 5	0	block4_conv3[0][0]
block5_conv1 (Conv2D)	(None, None, None, 5	2359808	block4_pool[0][0]
block5_conv2 (Conv2D)	(None, None, None, 5	2359808	block5_conv1[0][0]
block5_conv3 (Conv2D)	(None, None, None, 5	2359808	block5_conv2[0][0]
block5_pool (MaxPooling2D)	(None, None, None, 5	0	block5_conv3[0][0]
center_block1_conv (Conv2D)	(None, None, None, 5	2359296	block5_pool[0][0]
center_block1_bn (BatchNormaliz	(None, None, None, 5	2048	center_block1_conv[0][0]
center_block1_relu (Activation)	(None, None, None, 5	0	center_block1_bn[0][0]
center_block2_conv (Conv2D)	(None, None, None, 5	2359296	center_block1_relu[0][0]
center_block2_bn (BatchNormaliz	(None, None, None, 5	2048	center_block2_conv[0][0]
center_block2_relu (Activation)	(None, None, None, 5	0	center_block2_bn[0][0]
decoder_stage0_upsampling (UpSa	(None, None, None, 5	0	center_block2_relu[0][0]
decoder_stage0_concat (Concaten	(None, None, None, 1	0	decoder_stage0_upsampling[0][0] block5_conv3[0][0]
decoder_stage0a_conv (Conv2D)	(None, None, None, 2	2359296	decoder_stage0_concat[0][0]
decoder_stage0a_bn (BatchNormal	(None, None, None, 2	1024	decoder_stage0a_conv[0][0]
decoder_stage0a_relu (Activatio	(None, None, None, 2	0	decoder_stage0a_bn[0][0]
decoder_stage0b_conv (Conv2D)	(None, None, None, 2	589824	decoder_stage0a_relu[0][0]
decoder_stage0b_bn (BatchNormal	(None, None, None, 2	1024	decoder_stage0b_conv[0][0]
decoder_stage0b_relu (Activatio	(None, None, None, 2	0	decoder_stage0b_bn[0][0]

decoder_stage1_upsampling (UpSa	(None, None, None, 2	0	decoder_stage0b_relu[0][0]	
decoder_stage1_concat (Concaten	(None, None, None, 7	0	decoder_stage1_upsampling[0][0] block4_conv3[0][0]	
decoder_stage1a_conv (Conv2D)	(None, None, None, 1	884736	decoder_stage1_concat[0][0]	
decoder_stage1a_bn (BatchNormal	(None, None, None, 1	512	decoder_stage1a_conv[0][0]	
decoder_stage1a_relu (Activatio	(None, None, None, 1	0	decoder_stage1a_bn[0][0]	
decoder_stage1b_conv (Conv2D)	(None, None, None, 1	147456	decoder_stage1a_relu[0][0]	
decoder_stage1b_bn (BatchNormal	(None, None, None, 1	512	decoder_stage1b_conv[0][0]	
decoder_stage1b_relu (Activatio	(None, None, None, 1	0	decoder_stage1b_bn[0][0]	
decoder_stage2_upsampling (UpSa	(None, None, None, 1	0	decoder_stage1b_relu[0][0]	
decoder_stage2_concat (Concaten	(None, None, None, 3	0	decoder_stage2_upsampling[0][0] block3_conv3[0][0]	
decoder_stage2a_conv (Conv2D)	(None, None, None, 6	221184	decoder_stage2_concat[0][0]	
decoder_stage2a_bn (BatchNormal	(None, None, None, 6	256	decoder_stage2a_conv[0][0]	
decoder_stage2a_relu (Activatio	(None, None, None, 6	0	decoder_stage2a_bn[0][0]	
decoder_stage2b_conv (Conv2D)	(None, None, None, 6	36864	decoder_stage2a_relu[0][0]	
decoder_stage2b_bn (BatchNormal	(None, None, None, 6	256	decoder_stage2b_conv[0][0]	
decoder_stage2b_relu (Activatio	(None, None, None, 6	0	decoder_stage2b_bn[0][0]	
decoder_stage3_upsampling (UpSa	(None, None, None, 6	0	decoder_stage2b_relu[0][0]	
decoder_stage3_concat (Concaten	(None, None, None, 1	0	decoder_stage3_upsampling[0][0] block2_conv2[0][0]	
decoder_stage3a_conv (Conv2D)	(None, None, None, 3	55296	decoder_stage3_concat[0][0]	
decoder_stage3a_bn (BatchNormal	(None, None, None, 3	128	decoder_stage3a_conv[0][0]	
decoder_stage3a_relu (Activatio	(None, None, None, 3	0	decoder_stage3a_bn[0][0]	
decoder_stage3b_conv (Conv2D)	(None, None, None, 3	9216	decoder_stage3a_relu[0][0]	
decoder_stage3b_bn (BatchNormal	(None, None, None, 3	128	decoder_stage3b_conv[0][0]	
decoder_stage3b_relu (Activatio	(None, None, None, 3	0	decoder_stage3b_bn[0][0]	
decoder_stage4_upsampling (UpSa	(None, None, None, 3	0	decoder_stage3b_relu[0][0]	
decoder_stage4a_conv (Conv2D)	(None, None, None, 1	4608	decoder_stage4_upsampling[0][0]	
decoder_stage4a_bn (BatchNormal	(None, None, None, 1	64	decoder_stage4a_conv[0][0]	
decoder_stage4a_relu (Activatio	(None, None, None, 1	0	decoder_stage4a_bn[0][0]	
decoder_stage4b_conv (Conv2D)	(None, None, None, 1	2304	decoder_stage4a_relu[0][0]	
decoder_stage4b_bn (BatchNormal	(None, None, None, 1	64	decoder_stage4b_conv[0][0]	
decoder_stage4b_relu (Activatio	(None, None, None, 1	0	decoder_stage4b_bn[0][0]	
final_conv (Conv2D)	(None, None, None, 2	290	decoder_stage4b_relu[0][0]	
sigmoid (Activation)	(None, None, None, 2	0	final_conv[0][0]	

Total params: 23,752,418
Trainable params: 23,748,386
Non-trainable params: 4,032