**Unet Description**

**Ensembling of model**

**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 other’s as well such as desertification, flooding, soil erosion, increased greenhouse gases, and fewer crops etc [1]. In order to retore 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 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 1 and 2.

 A picture containing plant

Description automatically generated

**Forest Region**

Figure 1 Sample Image with non easily distinguishable regions

**Non-Forest Region Region**

**Non-Forest Region Region**

**Forest Region**

Figure Sample Image with Easily distinguishable regions

**Description of dataset**

# Methodology

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 1. 1st step consists of loading the training images along with their labelled masks and resize to cope with limited memory of the system. 2rd 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.

U-net Architecture

## 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 (site the dataset). 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.

**Table 1 Description of dataset**

|  |  |
| --- | --- |
| Data | 5108 labelled images |
| Resolution | 256x256 |

## 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 2 shows a general architecture of U-Net implemented with ResNet backbone. All the three models have been

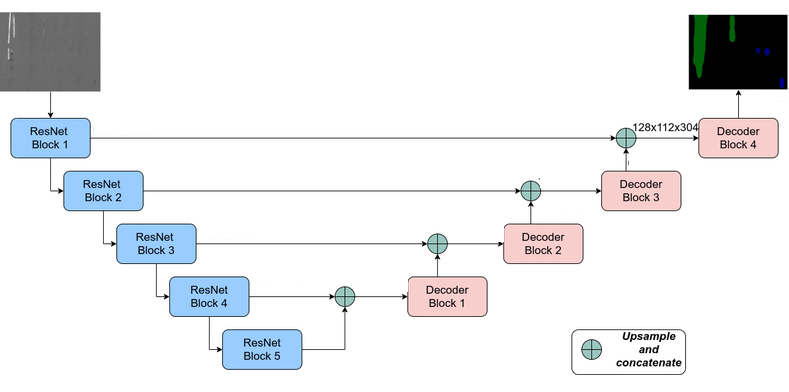


Figure U-Net with ResNet Backbone architecture

A picture containing text, clipart

Description automatically generated

Figure ResNet block ([3]"Understanding and visualizing ResNets", Medium, 2022. [Online]. Available: https://towardsdatascience.com/understanding-and-visualizing-resnets-442284831be8. [Accessed: 24- Feb- 2022].)

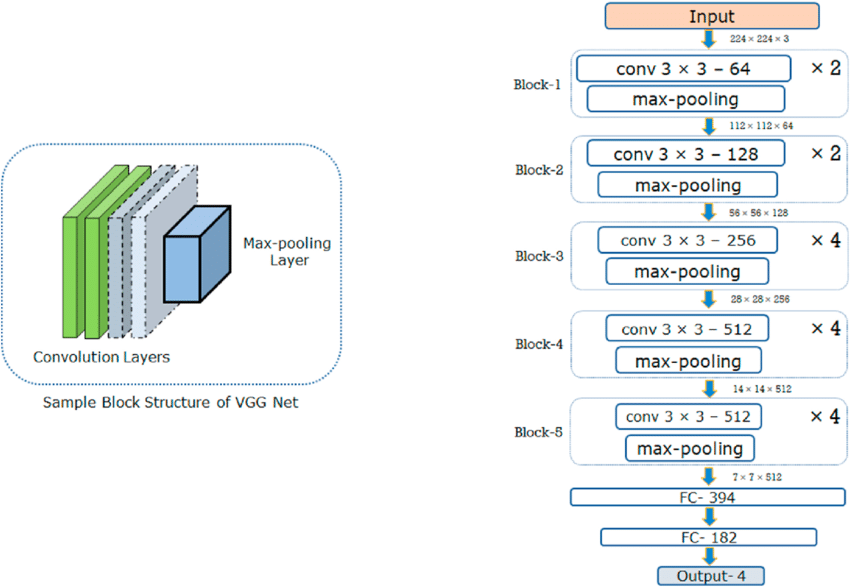


Figure Unit Block of Vgg19 Network [[2]2022. [Online]. Available: https://www.researchgate.net/figure/Network-architecture-of-finetuned-VGG19-a-Sample-Block-structure-of-VGG-Net-b\_fig5\_351921164. [Accessed: 24- Feb- 2022].]

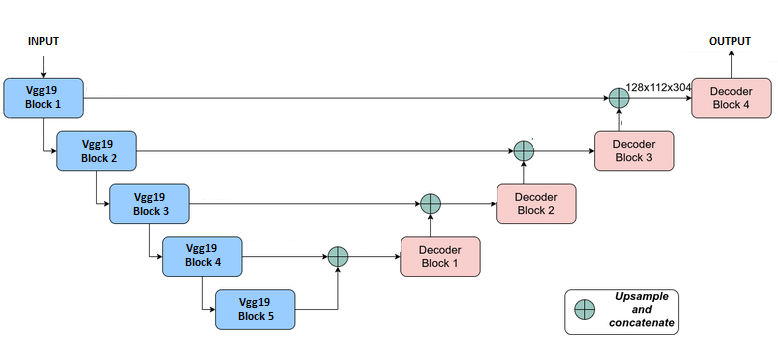


Figure U-Net with Vgg19 backbone acrhitecture

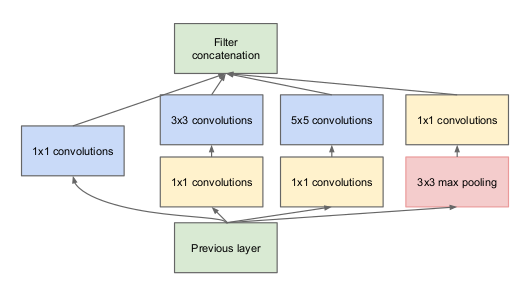


Figure Basic arcitecture block of InceptionV3 ([3]"Understanding and visualizing ResNets", Medium, 2022. [Online]. Available: https://towardsdatascience.com/understanding-and-visualizing-resnets-442284831be8. [Accessed: 24- Feb- 2022].)

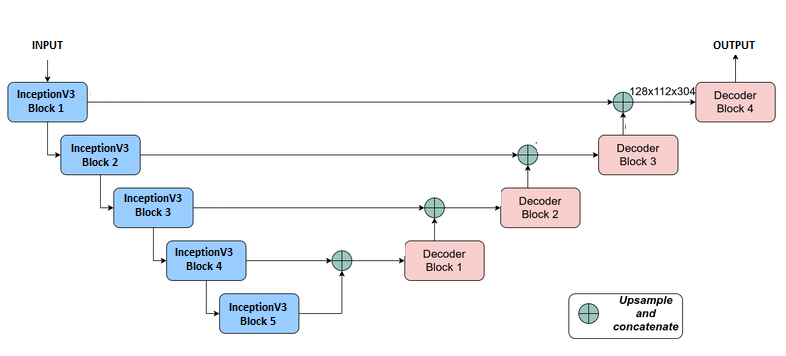


Figure U-Net with ResNet backbone acrhitecture

Summary of all three models is 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.

**Model Training**

3 different U-net architectures with 3 different backbones are individually trained on the same training dataset. Table-2 shows training parameters used during training of all 3 models.

**Table 2 Training Parameters**

|  |  |
| --- | --- |
| **Parameter** | **Name** |
| Loss Function | Binary\_focal\_dice\_loss |
| Metric1 | IOUScore (with threshold 0.5) |
| Metric2 | FScore (with threshold 0.5) |
| Optimizer | Adam |
| Batch Size | 8 |
| Epochs | 100 |

Chart, scatter chart

Description automatically generated Figure 9,10,11 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 Training progress for model 1

Figure 10 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 training data IoU reached to almost 99%

**Chart, scatter chart

Description automatically generated**

Figure Training Progress of model-2

Figure-11 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%.

Chart, line chart, histogram

Description automatically generated

Figure Training progress of model-3

**Ensembling of models for semantic segmentation**

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 (1)

Where

P= final prediction

P1 = prediction by model 1

P2 = prediction by model 2

P3 = prediction by model 3

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

**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 9-10 hence 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 9 -10.

Chart

Description automatically generated

Figure 12 Prediction with Bad IoU scores

Chart

Description automatically generated

Figure 13 Predictions with Good IoU scores

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.

**References**

[1]"Effects of Deforestation | The Pachamama Alliance", 2022. [Online]. Available: https://www.pachamama.org/effects-of-deforestation. [Accessed: 24- Feb- 2022].

# Appendix

## Model Summaries

**Model: "model\_1 (U-Net with res34 backbone "**

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Layer (type) Output Shape Param # Connected to

==================================================================================================

data (InputLayer) [(None, None, None, 0

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bn\_data (BatchNormalization) (None, None, None, 3 9 data[0][0]

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zero\_padding2d (ZeroPadding2D) (None, None, None, 3 0 bn\_data[0][0]

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conv0 (Conv2D) (None, None, None, 6 9408 zero\_padding2d[0][0]

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bn0 (BatchNormalization) (None, None, None, 6 256 conv0[0][0]

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relu0 (Activation) (None, None, None, 6 0 bn0[0][0]

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zero\_padding2d\_1 (ZeroPadding2D (None, None, None, 6 0 relu0[0][0]

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pooling0 (MaxPooling2D) (None, None, None, 6 0 zero\_padding2d\_1[0][0]

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stage1\_unit1\_bn1 (BatchNormaliz (None, None, None, 6 256 pooling0[0][0]

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stage1\_unit1\_relu1 (Activation) (None, None, None, 6 0 stage1\_unit1\_bn1[0][0]

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zero\_padding2d\_2 (ZeroPadding2D (None, None, None, 6 0 stage1\_unit1\_relu1[0][0]

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stage1\_unit1\_conv1 (Conv2D) (None, None, None, 6 36864 zero\_padding2d\_2[0][0]

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stage1\_unit1\_bn2 (BatchNormaliz (None, None, None, 6 256 stage1\_unit1\_conv1[0][0]

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stage1\_unit1\_relu2 (Activation) (None, None, None, 6 0 stage1\_unit1\_bn2[0][0]

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zero\_padding2d\_3 (ZeroPadding2D (None, None, None, 6 0 stage1\_unit1\_relu2[0][0]

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stage1\_unit1\_conv2 (Conv2D) (None, None, None, 6 36864 zero\_padding2d\_3[0][0]

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stage1\_unit1\_sc (Conv2D) (None, None, None, 6 4096 stage1\_unit1\_relu1[0][0]

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stage1\_unit2\_conv1 (Conv2D) (None, None, None, 6 36864 zero\_padding2d\_4[0][0]

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stage1\_unit3\_relu1 (Activation) (None, None, None, 6 0 stage1\_unit3\_bn1[0][0]

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stage1\_unit3\_conv1 (Conv2D) (None, None, None, 6 36864 zero\_padding2d\_6[0][0]

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stage1\_unit3\_relu2 (Activation) (None, None, None, 6 0 stage1\_unit3\_bn2[0][0]

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stage1\_unit3\_conv2 (Conv2D) (None, None, None, 6 36864 zero\_padding2d\_7[0][0]

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add\_2 (Add) (None, None, None, 6 0 stage1\_unit3\_conv2[0][0]

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stage2\_unit1\_bn1 (BatchNormaliz (None, None, None, 6 256 add\_2[0][0]

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stage2\_unit1\_relu1 (Activation) (None, None, None, 6 0 stage2\_unit1\_bn1[0][0]

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zero\_padding2d\_8 (ZeroPadding2D (None, None, None, 6 0 stage2\_unit1\_relu1[0][0]

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stage2\_unit1\_conv1 (Conv2D) (None, None, None, 1 73728 zero\_padding2d\_8[0][0]

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stage2\_unit1\_bn2 (BatchNormaliz (None, None, None, 1 512 stage2\_unit1\_conv1[0][0]

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stage2\_unit1\_relu2 (Activation) (None, None, None, 1 0 stage2\_unit1\_bn2[0][0]

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zero\_padding2d\_9 (ZeroPadding2D (None, None, None, 1 0 stage2\_unit1\_relu2[0][0]

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stage2\_unit1\_conv2 (Conv2D) (None, None, None, 1 147456 zero\_padding2d\_9[0][0]

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stage2\_unit1\_sc (Conv2D) (None, None, None, 1 8192 stage2\_unit1\_relu1[0][0]

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add\_3 (Add) (None, None, None, 1 0 stage2\_unit1\_conv2[0][0]

stage2\_unit1\_sc[0][0]

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stage2\_unit2\_bn1 (BatchNormaliz (None, None, None, 1 512 add\_3[0][0]

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stage2\_unit2\_relu1 (Activation) (None, None, None, 1 0 stage2\_unit2\_bn1[0][0]

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zero\_padding2d\_10 (ZeroPadding2 (None, None, None, 1 0 stage2\_unit2\_relu1[0][0]

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stage2\_unit2\_conv1 (Conv2D) (None, None, None, 1 147456 zero\_padding2d\_10[0][0]

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stage2\_unit2\_bn2 (BatchNormaliz (None, None, None, 1 512 stage2\_unit2\_conv1[0][0]

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stage2\_unit2\_relu2 (Activation) (None, None, None, 1 0 stage2\_unit2\_bn2[0][0]

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zero\_padding2d\_11 (ZeroPadding2 (None, None, None, 1 0 stage2\_unit2\_relu2[0][0]

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stage2\_unit2\_conv2 (Conv2D) (None, None, None, 1 147456 zero\_padding2d\_11[0][0]

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add\_4 (Add) (None, None, None, 1 0 stage2\_unit2\_conv2[0][0]

add\_3[0][0]

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stage2\_unit3\_bn1 (BatchNormaliz (None, None, None, 1 512 add\_4[0][0]

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stage2\_unit3\_relu1 (Activation) (None, None, None, 1 0 stage2\_unit3\_bn1[0][0]

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zero\_padding2d\_12 (ZeroPadding2 (None, None, None, 1 0 stage2\_unit3\_relu1[0][0]

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stage2\_unit3\_conv1 (Conv2D) (None, None, None, 1 147456 zero\_padding2d\_12[0][0]

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stage2\_unit3\_bn2 (BatchNormaliz (None, None, None, 1 512 stage2\_unit3\_conv1[0][0]

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stage2\_unit3\_relu2 (Activation) (None, None, None, 1 0 stage2\_unit3\_bn2[0][0]

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zero\_padding2d\_13 (ZeroPadding2 (None, None, None, 1 0 stage2\_unit3\_relu2[0][0]

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stage2\_unit3\_conv2 (Conv2D) (None, None, None, 1 147456 zero\_padding2d\_13[0][0]

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add\_5 (Add) (None, None, None, 1 0 stage2\_unit3\_conv2[0][0]

add\_4[0][0]

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stage2\_unit4\_bn1 (BatchNormaliz (None, None, None, 1 512 add\_5[0][0]

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stage2\_unit4\_relu1 (Activation) (None, None, None, 1 0 stage2\_unit4\_bn1[0][0]

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zero\_padding2d\_14 (ZeroPadding2 (None, None, None, 1 0 stage2\_unit4\_relu1[0][0]

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stage2\_unit4\_conv1 (Conv2D) (None, None, None, 1 147456 zero\_padding2d\_14[0][0]

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stage2\_unit4\_bn2 (BatchNormaliz (None, None, None, 1 512 stage2\_unit4\_conv1[0][0]

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stage2\_unit4\_relu2 (Activation) (None, None, None, 1 0 stage2\_unit4\_bn2[0][0]

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zero\_padding2d\_15 (ZeroPadding2 (None, None, None, 1 0 stage2\_unit4\_relu2[0][0]

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stage2\_unit4\_conv2 (Conv2D) (None, None, None, 1 147456 zero\_padding2d\_15[0][0]

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add\_6 (Add) (None, None, None, 1 0 stage2\_unit4\_conv2[0][0]

add\_5[0][0]

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stage3\_unit1\_bn1 (BatchNormaliz (None, None, None, 1 512 add\_6[0][0]

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stage3\_unit1\_relu1 (Activation) (None, None, None, 1 0 stage3\_unit1\_bn1[0][0]

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zero\_padding2d\_16 (ZeroPadding2 (None, None, None, 1 0 stage3\_unit1\_relu1[0][0]

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stage3\_unit1\_conv1 (Conv2D) (None, None, None, 2 294912 zero\_padding2d\_16[0][0]

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stage3\_unit1\_bn2 (BatchNormaliz (None, None, None, 2 1024 stage3\_unit1\_conv1[0][0]

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stage3\_unit1\_relu2 (Activation) (None, None, None, 2 0 stage3\_unit1\_bn2[0][0]

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zero\_padding2d\_17 (ZeroPadding2 (None, None, None, 2 0 stage3\_unit1\_relu2[0][0]

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stage3\_unit1\_conv2 (Conv2D) (None, None, None, 2 589824 zero\_padding2d\_17[0][0]

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stage3\_unit1\_sc (Conv2D) (None, None, None, 2 32768 stage3\_unit1\_relu1[0][0]

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add\_7 (Add) (None, None, None, 2 0 stage3\_unit1\_conv2[0][0]

stage3\_unit1\_sc[0][0]

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stage3\_unit2\_bn1 (BatchNormaliz (None, None, None, 2 1024 add\_7[0][0]

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stage3\_unit2\_relu1 (Activation) (None, None, None, 2 0 stage3\_unit2\_bn1[0][0]

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zero\_padding2d\_18 (ZeroPadding2 (None, None, None, 2 0 stage3\_unit2\_relu1[0][0]

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stage3\_unit2\_conv1 (Conv2D) (None, None, None, 2 589824 zero\_padding2d\_18[0][0]

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stage3\_unit2\_bn2 (BatchNormaliz (None, None, None, 2 1024 stage3\_unit2\_conv1[0][0]

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stage3\_unit2\_relu2 (Activation) (None, None, None, 2 0 stage3\_unit2\_bn2[0][0]

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zero\_padding2d\_19 (ZeroPadding2 (None, None, None, 2 0 stage3\_unit2\_relu2[0][0]

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stage3\_unit2\_conv2 (Conv2D) (None, None, None, 2 589824 zero\_padding2d\_19[0][0]

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add\_8 (Add) (None, None, None, 2 0 stage3\_unit2\_conv2[0][0]

add\_7[0][0]

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stage3\_unit3\_bn1 (BatchNormaliz (None, None, None, 2 1024 add\_8[0][0]

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stage3\_unit3\_relu1 (Activation) (None, None, None, 2 0 stage3\_unit3\_bn1[0][0]

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zero\_padding2d\_20 (ZeroPadding2 (None, None, None, 2 0 stage3\_unit3\_relu1[0][0]

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stage3\_unit3\_conv1 (Conv2D) (None, None, None, 2 589824 zero\_padding2d\_20[0][0]

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stage3\_unit3\_bn2 (BatchNormaliz (None, None, None, 2 1024 stage3\_unit3\_conv1[0][0]

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stage3\_unit3\_relu2 (Activation) (None, None, None, 2 0 stage3\_unit3\_bn2[0][0]

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zero\_padding2d\_21 (ZeroPadding2 (None, None, None, 2 0 stage3\_unit3\_relu2[0][0]

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stage3\_unit3\_conv2 (Conv2D) (None, None, None, 2 589824 zero\_padding2d\_21[0][0]

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add\_9 (Add) (None, None, None, 2 0 stage3\_unit3\_conv2[0][0]

add\_8[0][0]

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stage3\_unit4\_bn1 (BatchNormaliz (None, None, None, 2 1024 add\_9[0][0]

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stage3\_unit4\_relu1 (Activation) (None, None, None, 2 0 stage3\_unit4\_bn1[0][0]

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zero\_padding2d\_22 (ZeroPadding2 (None, None, None, 2 0 stage3\_unit4\_relu1[0][0]

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stage3\_unit4\_conv1 (Conv2D) (None, None, None, 2 589824 zero\_padding2d\_22[0][0]

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stage3\_unit4\_bn2 (BatchNormaliz (None, None, None, 2 1024 stage3\_unit4\_conv1[0][0]

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stage3\_unit4\_relu2 (Activation) (None, None, None, 2 0 stage3\_unit4\_bn2[0][0]

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zero\_padding2d\_23 (ZeroPadding2 (None, None, None, 2 0 stage3\_unit4\_relu2[0][0]

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stage3\_unit4\_conv2 (Conv2D) (None, None, None, 2 589824 zero\_padding2d\_23[0][0]

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add\_10 (Add) (None, None, None, 2 0 stage3\_unit4\_conv2[0][0]

add\_9[0][0]

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stage3\_unit5\_bn1 (BatchNormaliz (None, None, None, 2 1024 add\_10[0][0]

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stage3\_unit5\_relu1 (Activation) (None, None, None, 2 0 stage3\_unit5\_bn1[0][0]

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zero\_padding2d\_24 (ZeroPadding2 (None, None, None, 2 0 stage3\_unit5\_relu1[0][0]

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stage3\_unit5\_conv1 (Conv2D) (None, None, None, 2 589824 zero\_padding2d\_24[0][0]

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stage3\_unit5\_bn2 (BatchNormaliz (None, None, None, 2 1024 stage3\_unit5\_conv1[0][0]

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stage3\_unit5\_relu2 (Activation) (None, None, None, 2 0 stage3\_unit5\_bn2[0][0]

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zero\_padding2d\_25 (ZeroPadding2 (None, None, None, 2 0 stage3\_unit5\_relu2[0][0]

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stage3\_unit5\_conv2 (Conv2D) (None, None, None, 2 589824 zero\_padding2d\_25[0][0]

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add\_11 (Add) (None, None, None, 2 0 stage3\_unit5\_conv2[0][0]

add\_10[0][0]

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stage3\_unit6\_bn1 (BatchNormaliz (None, None, None, 2 1024 add\_11[0][0]

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stage3\_unit6\_relu1 (Activation) (None, None, None, 2 0 stage3\_unit6\_bn1[0][0]

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zero\_padding2d\_26 (ZeroPadding2 (None, None, None, 2 0 stage3\_unit6\_relu1[0][0]

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stage3\_unit6\_conv1 (Conv2D) (None, None, None, 2 589824 zero\_padding2d\_26[0][0]

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stage3\_unit6\_bn2 (BatchNormaliz (None, None, None, 2 1024 stage3\_unit6\_conv1[0][0]

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stage3\_unit6\_relu2 (Activation) (None, None, None, 2 0 stage3\_unit6\_bn2[0][0]

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zero\_padding2d\_27 (ZeroPadding2 (None, None, None, 2 0 stage3\_unit6\_relu2[0][0]

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stage3\_unit6\_conv2 (Conv2D) (None, None, None, 2 589824 zero\_padding2d\_27[0][0]

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add\_12 (Add) (None, None, None, 2 0 stage3\_unit6\_conv2[0][0]

add\_11[0][0]

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stage4\_unit1\_bn1 (BatchNormaliz (None, None, None, 2 1024 add\_12[0][0]

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stage4\_unit1\_relu1 (Activation) (None, None, None, 2 0 stage4\_unit1\_bn1[0][0]

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zero\_padding2d\_28 (ZeroPadding2 (None, None, None, 2 0 stage4\_unit1\_relu1[0][0]

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stage4\_unit1\_conv1 (Conv2D) (None, None, None, 5 1179648 zero\_padding2d\_28[0][0]

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stage4\_unit1\_bn2 (BatchNormaliz (None, None, None, 5 2048 stage4\_unit1\_conv1[0][0]

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stage4\_unit1\_relu2 (Activation) (None, None, None, 5 0 stage4\_unit1\_bn2[0][0]

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zero\_padding2d\_29 (ZeroPadding2 (None, None, None, 5 0 stage4\_unit1\_relu2[0][0]

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stage4\_unit1\_conv2 (Conv2D) (None, None, None, 5 2359296 zero\_padding2d\_29[0][0]

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stage4\_unit1\_sc (Conv2D) (None, None, None, 5 131072 stage4\_unit1\_relu1[0][0]

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add\_13 (Add) (None, None, None, 5 0 stage4\_unit1\_conv2[0][0]

stage4\_unit1\_sc[0][0]

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stage4\_unit2\_bn1 (BatchNormaliz (None, None, None, 5 2048 add\_13[0][0]

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stage4\_unit2\_relu1 (Activation) (None, None, None, 5 0 stage4\_unit2\_bn1[0][0]

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zero\_padding2d\_30 (ZeroPadding2 (None, None, None, 5 0 stage4\_unit2\_relu1[0][0]

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stage4\_unit2\_conv1 (Conv2D) (None, None, None, 5 2359296 zero\_padding2d\_30[0][0]

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stage4\_unit2\_bn2 (BatchNormaliz (None, None, None, 5 2048 stage4\_unit2\_conv1[0][0]

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stage4\_unit2\_relu2 (Activation) (None, None, None, 5 0 stage4\_unit2\_bn2[0][0]

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zero\_padding2d\_31 (ZeroPadding2 (None, None, None, 5 0 stage4\_unit2\_relu2[0][0]

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stage4\_unit2\_conv2 (Conv2D) (None, None, None, 5 2359296 zero\_padding2d\_31[0][0]

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add\_14 (Add) (None, None, None, 5 0 stage4\_unit2\_conv2[0][0]

add\_13[0][0]

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stage4\_unit3\_bn1 (BatchNormaliz (None, None, None, 5 2048 add\_14[0][0]

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stage4\_unit3\_relu1 (Activation) (None, None, None, 5 0 stage4\_unit3\_bn1[0][0]

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zero\_padding2d\_32 (ZeroPadding2 (None, None, None, 5 0 stage4\_unit3\_relu1[0][0]

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stage4\_unit3\_conv1 (Conv2D) (None, None, None, 5 2359296 zero\_padding2d\_32[0][0]

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stage4\_unit3\_bn2 (BatchNormaliz (None, None, None, 5 2048 stage4\_unit3\_conv1[0][0]

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stage4\_unit3\_relu2 (Activation) (None, None, None, 5 0 stage4\_unit3\_bn2[0][0]

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zero\_padding2d\_33 (ZeroPadding2 (None, None, None, 5 0 stage4\_unit3\_relu2[0][0]

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stage4\_unit3\_conv2 (Conv2D) (None, None, None, 5 2359296 zero\_padding2d\_33[0][0]

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add\_15 (Add) (None, None, None, 5 0 stage4\_unit3\_conv2[0][0]

add\_14[0][0]

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bn1 (BatchNormalization) (None, None, None, 5 2048 add\_15[0][0]

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

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decoder\_stage0\_upsampling (UpSa (None, None, None, 5 0 relu1[0][0]

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decoder\_stage0\_concat (Concaten (None, None, None, 7 0 decoder\_stage0\_upsampling[0][0]

stage4\_unit1\_relu1[0][0]

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decoder\_stage0a\_conv (Conv2D) (None, None, None, 2 1769472 decoder\_stage0\_concat[0][0]

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decoder\_stage0a\_bn (BatchNormal (None, None, None, 2 1024 decoder\_stage0a\_conv[0][0]

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decoder\_stage0a\_relu (Activatio (None, None, None, 2 0 decoder\_stage0a\_bn[0][0]

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decoder\_stage0b\_conv (Conv2D) (None, None, None, 2 589824 decoder\_stage0a\_relu[0][0]

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decoder\_stage0b\_bn (BatchNormal (None, None, None, 2 1024 decoder\_stage0b\_conv[0][0]

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decoder\_stage0b\_relu (Activatio (None, None, None, 2 0 decoder\_stage0b\_bn[0][0]

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decoder\_stage1\_upsampling (UpSa (None, None, None, 2 0 decoder\_stage0b\_relu[0][0]

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decoder\_stage1\_concat (Concaten (None, None, None, 3 0 decoder\_stage1\_upsampling[0][0]

stage3\_unit1\_relu1[0][0]

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decoder\_stage1a\_conv (Conv2D) (None, None, None, 1 442368 decoder\_stage1\_concat[0][0]

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decoder\_stage1a\_bn (BatchNormal (None, None, None, 1 512 decoder\_stage1a\_conv[0][0]

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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]

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decoder\_stage1b\_bn (BatchNormal (None, None, None, 1 512 decoder\_stage1b\_conv[0][0]

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decoder\_stage1b\_relu (Activatio (None, None, None, 1 0 decoder\_stage1b\_bn[0][0]

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decoder\_stage2\_upsampling (UpSa (None, None, None, 1 0 decoder\_stage1b\_relu[0][0]

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decoder\_stage2\_concat (Concaten (None, None, None, 1 0 decoder\_stage2\_upsampling[0][0]

stage2\_unit1\_relu1[0][0]

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decoder\_stage2a\_conv (Conv2D) (None, None, None, 6 110592 decoder\_stage2\_concat[0][0]

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decoder\_stage2a\_bn (BatchNormal (None, None, None, 6 256 decoder\_stage2a\_conv[0][0]

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decoder\_stage2a\_relu (Activatio (None, None, None, 6 0 decoder\_stage2a\_bn[0][0]

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decoder\_stage2b\_conv (Conv2D) (None, None, None, 6 36864 decoder\_stage2a\_relu[0][0]

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decoder\_stage2b\_bn (BatchNormal (None, None, None, 6 256 decoder\_stage2b\_conv[0][0]

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decoder\_stage2b\_relu (Activatio (None, None, None, 6 0 decoder\_stage2b\_bn[0][0]

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decoder\_stage3\_upsampling (UpSa (None, None, None, 6 0 decoder\_stage2b\_relu[0][0]

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decoder\_stage3\_concat (Concaten (None, None, None, 1 0 decoder\_stage3\_upsampling[0][0]

relu0[0][0]

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decoder\_stage3a\_conv (Conv2D) (None, None, None, 3 36864 decoder\_stage3\_concat[0][0]

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decoder\_stage3a\_bn (BatchNormal (None, None, None, 3 128 decoder\_stage3a\_conv[0][0]

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decoder\_stage3a\_relu (Activatio (None, None, None, 3 0 decoder\_stage3a\_bn[0][0]

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decoder\_stage3b\_conv (Conv2D) (None, None, None, 3 9216 decoder\_stage3a\_relu[0][0]

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decoder\_stage3b\_bn (BatchNormal (None, None, None, 3 128 decoder\_stage3b\_conv[0][0]

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decoder\_stage3b\_relu (Activatio (None, None, None, 3 0 decoder\_stage3b\_bn[0][0]

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decoder\_stage4\_upsampling (UpSa (None, None, None, 3 0 decoder\_stage3b\_relu[0][0]

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decoder\_stage4a\_conv (Conv2D) (None, None, None, 1 4608 decoder\_stage4\_upsampling[0][0]

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decoder\_stage4a\_bn (BatchNormal (None, None, None, 1 64 decoder\_stage4a\_conv[0][0]

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decoder\_stage4a\_relu (Activatio (None, None, None, 1 0 decoder\_stage4a\_bn[0][0]

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decoder\_stage4b\_conv (Conv2D) (None, None, None, 1 2304 decoder\_stage4a\_relu[0][0]

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decoder\_stage4b\_bn (BatchNormal (None, None, None, 1 64 decoder\_stage4b\_conv[0][0]

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decoder\_stage4b\_relu (Activatio (None, None, None, 1 0 decoder\_stage4b\_bn[0][0]

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final\_conv (Conv2D) (None, None, None, 2 290 decoder\_stage4b\_relu[0][0]

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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

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

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Layer (type) Output Shape Param # Connected to

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input\_1 (InputLayer) [(None, None, None, 0

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conv2d (Conv2D) (None, None, None, 3 864 input\_1[0][0]

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batch\_normalization (BatchNorma (None, None, None, 3 96 conv2d[0][0]

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activation (Activation) (None, None, None, 3 0 batch\_normalization[0][0]

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conv2d\_1 (Conv2D) (None, None, None, 3 9216 activation[0][0]

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batch\_normalization\_1 (BatchNor (None, None, None, 3 96 conv2d\_1[0][0]

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activation\_1 (Activation) (None, None, None, 3 0 batch\_normalization\_1[0][0]

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conv2d\_2 (Conv2D) (None, None, None, 6 18432 activation\_1[0][0]

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batch\_normalization\_2 (BatchNor (None, None, None, 6 192 conv2d\_2[0][0]

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activation\_2 (Activation) (None, None, None, 6 0 batch\_normalization\_2[0][0]

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max\_pooling2d (MaxPooling2D) (None, None, None, 6 0 activation\_2[0][0]

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conv2d\_3 (Conv2D) (None, None, None, 8 5120 max\_pooling2d[0][0]

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batch\_normalization\_3 (BatchNor (None, None, None, 8 240 conv2d\_3[0][0]

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activation\_3 (Activation) (None, None, None, 8 0 batch\_normalization\_3[0][0]

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conv2d\_4 (Conv2D) (None, None, None, 1 138240 activation\_3[0][0]

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batch\_normalization\_4 (BatchNor (None, None, None, 1 576 conv2d\_4[0][0]

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activation\_4 (Activation) (None, None, None, 1 0 batch\_normalization\_4[0][0]

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max\_pooling2d\_1 (MaxPooling2D) (None, None, None, 1 0 activation\_4[0][0]

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conv2d\_8 (Conv2D) (None, None, None, 6 12288 max\_pooling2d\_1[0][0]

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batch\_normalization\_8 (BatchNor (None, None, None, 6 192 conv2d\_8[0][0]

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activation\_8 (Activation) (None, None, None, 6 0 batch\_normalization\_8[0][0]

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conv2d\_6 (Conv2D) (None, None, None, 4 9216 max\_pooling2d\_1[0][0]

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conv2d\_9 (Conv2D) (None, None, None, 9 55296 activation\_8[0][0]

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batch\_normalization\_6 (BatchNor (None, None, None, 4 144 conv2d\_6[0][0]

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batch\_normalization\_9 (BatchNor (None, None, None, 9 288 conv2d\_9[0][0]

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activation\_6 (Activation) (None, None, None, 4 0 batch\_normalization\_6[0][0]

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activation\_9 (Activation) (None, None, None, 9 0 batch\_normalization\_9[0][0]

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average\_pooling2d (AveragePooli (None, None, None, 1 0 max\_pooling2d\_1[0][0]

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conv2d\_5 (Conv2D) (None, None, None, 6 12288 max\_pooling2d\_1[0][0]

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conv2d\_7 (Conv2D) (None, None, None, 6 76800 activation\_6[0][0]

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conv2d\_10 (Conv2D) (None, None, None, 9 82944 activation\_9[0][0]

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conv2d\_11 (Conv2D) (None, None, None, 3 6144 average\_pooling2d[0][0]

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batch\_normalization\_5 (BatchNor (None, None, None, 6 192 conv2d\_5[0][0]

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batch\_normalization\_7 (BatchNor (None, None, None, 6 192 conv2d\_7[0][0]

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batch\_normalization\_10 (BatchNo (None, None, None, 9 288 conv2d\_10[0][0]

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batch\_normalization\_11 (BatchNo (None, None, None, 3 96 conv2d\_11[0][0]

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activation\_5 (Activation) (None, None, None, 6 0 batch\_normalization\_5[0][0]

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activation\_7 (Activation) (None, None, None, 6 0 batch\_normalization\_7[0][0]

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activation\_10 (Activation) (None, None, None, 9 0 batch\_normalization\_10[0][0]

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activation\_11 (Activation) (None, None, None, 3 0 batch\_normalization\_11[0][0]

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mixed0 (Concatenate) (None, None, None, 2 0 activation\_5[0][0]

activation\_7[0][0]

activation\_10[0][0]

activation\_11[0][0]

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conv2d\_15 (Conv2D) (None, None, None, 6 16384 mixed0[0][0]

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batch\_normalization\_15 (BatchNo (None, None, None, 6 192 conv2d\_15[0][0]

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activation\_15 (Activation) (None, None, None, 6 0 batch\_normalization\_15[0][0]

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conv2d\_13 (Conv2D) (None, None, None, 4 12288 mixed0[0][0]

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conv2d\_16 (Conv2D) (None, None, None, 9 55296 activation\_15[0][0]

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batch\_normalization\_13 (BatchNo (None, None, None, 4 144 conv2d\_13[0][0]

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batch\_normalization\_16 (BatchNo (None, None, None, 9 288 conv2d\_16[0][0]

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activation\_13 (Activation) (None, None, None, 4 0 batch\_normalization\_13[0][0]

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activation\_16 (Activation) (None, None, None, 9 0 batch\_normalization\_16[0][0]

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average\_pooling2d\_1 (AveragePoo (None, None, None, 2 0 mixed0[0][0]

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conv2d\_12 (Conv2D) (None, None, None, 6 16384 mixed0[0][0]

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conv2d\_14 (Conv2D) (None, None, None, 6 76800 activation\_13[0][0]

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conv2d\_17 (Conv2D) (None, None, None, 9 82944 activation\_16[0][0]

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conv2d\_18 (Conv2D) (None, None, None, 6 16384 average\_pooling2d\_1[0][0]

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batch\_normalization\_12 (BatchNo (None, None, None, 6 192 conv2d\_12[0][0]

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batch\_normalization\_14 (BatchNo (None, None, None, 6 192 conv2d\_14[0][0]

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batch\_normalization\_17 (BatchNo (None, None, None, 9 288 conv2d\_17[0][0]

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batch\_normalization\_18 (BatchNo (None, None, None, 6 192 conv2d\_18[0][0]

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activation\_12 (Activation) (None, None, None, 6 0 batch\_normalization\_12[0][0]

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activation\_14 (Activation) (None, None, None, 6 0 batch\_normalization\_14[0][0]

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activation\_17 (Activation) (None, None, None, 9 0 batch\_normalization\_17[0][0]

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activation\_18 (Activation) (None, None, None, 6 0 batch\_normalization\_18[0][0]

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mixed1 (Concatenate) (None, None, None, 2 0 activation\_12[0][0]

activation\_14[0][0]

activation\_17[0][0]

activation\_18[0][0]

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conv2d\_22 (Conv2D) (None, None, None, 6 18432 mixed1[0][0]

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batch\_normalization\_22 (BatchNo (None, None, None, 6 192 conv2d\_22[0][0]

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activation\_22 (Activation) (None, None, None, 6 0 batch\_normalization\_22[0][0]

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conv2d\_20 (Conv2D) (None, None, None, 4 13824 mixed1[0][0]

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conv2d\_23 (Conv2D) (None, None, None, 9 55296 activation\_22[0][0]

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batch\_normalization\_20 (BatchNo (None, None, None, 4 144 conv2d\_20[0][0]

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batch\_normalization\_23 (BatchNo (None, None, None, 9 288 conv2d\_23[0][0]

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activation\_20 (Activation) (None, None, None, 4 0 batch\_normalization\_20[0][0]

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activation\_23 (Activation) (None, None, None, 9 0 batch\_normalization\_23[0][0]

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average\_pooling2d\_2 (AveragePoo (None, None, None, 2 0 mixed1[0][0]

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conv2d\_19 (Conv2D) (None, None, None, 6 18432 mixed1[0][0]

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conv2d\_21 (Conv2D) (None, None, None, 6 76800 activation\_20[0][0]

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conv2d\_24 (Conv2D) (None, None, None, 9 82944 activation\_23[0][0]

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conv2d\_25 (Conv2D) (None, None, None, 6 18432 average\_pooling2d\_2[0][0]

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batch\_normalization\_19 (BatchNo (None, None, None, 6 192 conv2d\_19[0][0]

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batch\_normalization\_21 (BatchNo (None, None, None, 6 192 conv2d\_21[0][0]

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batch\_normalization\_24 (BatchNo (None, None, None, 9 288 conv2d\_24[0][0]

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batch\_normalization\_25 (BatchNo (None, None, None, 6 192 conv2d\_25[0][0]

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activation\_19 (Activation) (None, None, None, 6 0 batch\_normalization\_19[0][0]

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activation\_21 (Activation) (None, None, None, 6 0 batch\_normalization\_21[0][0]

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activation\_24 (Activation) (None, None, None, 9 0 batch\_normalization\_24[0][0]

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activation\_25 (Activation) (None, None, None, 6 0 batch\_normalization\_25[0][0]

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mixed2 (Concatenate) (None, None, None, 2 0 activation\_19[0][0]

activation\_21[0][0]

activation\_24[0][0]

activation\_25[0][0]

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conv2d\_27 (Conv2D) (None, None, None, 6 18432 mixed2[0][0]

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batch\_normalization\_27 (BatchNo (None, None, None, 6 192 conv2d\_27[0][0]

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activation\_27 (Activation) (None, None, None, 6 0 batch\_normalization\_27[0][0]

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conv2d\_28 (Conv2D) (None, None, None, 9 55296 activation\_27[0][0]

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batch\_normalization\_28 (BatchNo (None, None, None, 9 288 conv2d\_28[0][0]

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activation\_28 (Activation) (None, None, None, 9 0 batch\_normalization\_28[0][0]

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conv2d\_26 (Conv2D) (None, None, None, 3 995328 mixed2[0][0]

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conv2d\_29 (Conv2D) (None, None, None, 9 82944 activation\_28[0][0]

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batch\_normalization\_26 (BatchNo (None, None, None, 3 1152 conv2d\_26[0][0]

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batch\_normalization\_29 (BatchNo (None, None, None, 9 288 conv2d\_29[0][0]

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activation\_26 (Activation) (None, None, None, 3 0 batch\_normalization\_26[0][0]

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activation\_29 (Activation) (None, None, None, 9 0 batch\_normalization\_29[0][0]

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max\_pooling2d\_2 (MaxPooling2D) (None, None, None, 2 0 mixed2[0][0]

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mixed3 (Concatenate) (None, None, None, 7 0 activation\_26[0][0]

activation\_29[0][0]

max\_pooling2d\_2[0][0]

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conv2d\_34 (Conv2D) (None, None, None, 1 98304 mixed3[0][0]

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batch\_normalization\_34 (BatchNo (None, None, None, 1 384 conv2d\_34[0][0]

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activation\_34 (Activation) (None, None, None, 1 0 batch\_normalization\_34[0][0]

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conv2d\_35 (Conv2D) (None, None, None, 1 114688 activation\_34[0][0]

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batch\_normalization\_35 (BatchNo (None, None, None, 1 384 conv2d\_35[0][0]

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activation\_35 (Activation) (None, None, None, 1 0 batch\_normalization\_35[0][0]

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conv2d\_31 (Conv2D) (None, None, None, 1 98304 mixed3[0][0]

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conv2d\_36 (Conv2D) (None, None, None, 1 114688 activation\_35[0][0]

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batch\_normalization\_31 (BatchNo (None, None, None, 1 384 conv2d\_31[0][0]

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batch\_normalization\_36 (BatchNo (None, None, None, 1 384 conv2d\_36[0][0]

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activation\_31 (Activation) (None, None, None, 1 0 batch\_normalization\_31[0][0]

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activation\_36 (Activation) (None, None, None, 1 0 batch\_normalization\_36[0][0]

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conv2d\_32 (Conv2D) (None, None, None, 1 114688 activation\_31[0][0]

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conv2d\_37 (Conv2D) (None, None, None, 1 114688 activation\_36[0][0]

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batch\_normalization\_32 (BatchNo (None, None, None, 1 384 conv2d\_32[0][0]

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batch\_normalization\_37 (BatchNo (None, None, None, 1 384 conv2d\_37[0][0]

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activation\_32 (Activation) (None, None, None, 1 0 batch\_normalization\_32[0][0]

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activation\_37 (Activation) (None, None, None, 1 0 batch\_normalization\_37[0][0]

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average\_pooling2d\_3 (AveragePoo (None, None, None, 7 0 mixed3[0][0]

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conv2d\_30 (Conv2D) (None, None, None, 1 147456 mixed3[0][0]

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conv2d\_33 (Conv2D) (None, None, None, 1 172032 activation\_32[0][0]

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conv2d\_38 (Conv2D) (None, None, None, 1 172032 activation\_37[0][0]

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conv2d\_39 (Conv2D) (None, None, None, 1 147456 average\_pooling2d\_3[0][0]

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batch\_normalization\_30 (BatchNo (None, None, None, 1 576 conv2d\_30[0][0]

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batch\_normalization\_33 (BatchNo (None, None, None, 1 576 conv2d\_33[0][0]

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batch\_normalization\_38 (BatchNo (None, None, None, 1 576 conv2d\_38[0][0]

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batch\_normalization\_39 (BatchNo (None, None, None, 1 576 conv2d\_39[0][0]

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activation\_30 (Activation) (None, None, None, 1 0 batch\_normalization\_30[0][0]

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activation\_33 (Activation) (None, None, None, 1 0 batch\_normalization\_33[0][0]

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activation\_38 (Activation) (None, None, None, 1 0 batch\_normalization\_38[0][0]

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activation\_39 (Activation) (None, None, None, 1 0 batch\_normalization\_39[0][0]

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mixed4 (Concatenate) (None, None, None, 7 0 activation\_30[0][0]

activation\_33[0][0]

activation\_38[0][0]

activation\_39[0][0]

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conv2d\_44 (Conv2D) (None, None, None, 1 122880 mixed4[0][0]

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batch\_normalization\_44 (BatchNo (None, None, None, 1 480 conv2d\_44[0][0]

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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]

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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]

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conv2d\_41 (Conv2D) (None, None, None, 1 122880 mixed4[0][0]

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conv2d\_46 (Conv2D) (None, None, None, 1 179200 activation\_45[0][0]

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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]

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conv2d\_42 (Conv2D) (None, None, None, 1 179200 activation\_41[0][0]

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conv2d\_47 (Conv2D) (None, None, None, 1 179200 activation\_46[0][0]

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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]

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average\_pooling2d\_4 (AveragePoo (None, None, None, 7 0 mixed4[0][0]

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conv2d\_40 (Conv2D) (None, None, None, 1 147456 mixed4[0][0]

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conv2d\_43 (Conv2D) (None, None, None, 1 215040 activation\_42[0][0]

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conv2d\_48 (Conv2D) (None, None, None, 1 215040 activation\_47[0][0]

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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]

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activation\_43 (Activation) (None, None, None, 1 0 batch\_normalization\_43[0][0]

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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]

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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]

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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]

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conv2d\_64 (Conv2D) (None, None, None, 1 147456 mixed6[0][0]

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batch\_normalization\_64 (BatchNo (None, None, None, 1 576 conv2d\_64[0][0]

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activation\_64 (Activation) (None, None, None, 1 0 batch\_normalization\_64[0][0]

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conv2d\_65 (Conv2D) (None, None, None, 1 258048 activation\_64[0][0]

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batch\_normalization\_65 (BatchNo (None, None, None, 1 576 conv2d\_65[0][0]

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activation\_65 (Activation) (None, None, None, 1 0 batch\_normalization\_65[0][0]

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conv2d\_61 (Conv2D) (None, None, None, 1 147456 mixed6[0][0]

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conv2d\_66 (Conv2D) (None, None, None, 1 258048 activation\_65[0][0]

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batch\_normalization\_61 (BatchNo (None, None, None, 1 576 conv2d\_61[0][0]

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batch\_normalization\_66 (BatchNo (None, None, None, 1 576 conv2d\_66[0][0]

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activation\_61 (Activation) (None, None, None, 1 0 batch\_normalization\_61[0][0]

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activation\_66 (Activation) (None, None, None, 1 0 batch\_normalization\_66[0][0]

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conv2d\_62 (Conv2D) (None, None, None, 1 258048 activation\_61[0][0]

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conv2d\_67 (Conv2D) (None, None, None, 1 258048 activation\_66[0][0]

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batch\_normalization\_62 (BatchNo (None, None, None, 1 576 conv2d\_62[0][0]

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batch\_normalization\_67 (BatchNo (None, None, None, 1 576 conv2d\_67[0][0]

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activation\_62 (Activation) (None, None, None, 1 0 batch\_normalization\_62[0][0]

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activation\_67 (Activation) (None, None, None, 1 0 batch\_normalization\_67[0][0]

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average\_pooling2d\_6 (AveragePoo (None, None, None, 7 0 mixed6[0][0]

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conv2d\_60 (Conv2D) (None, None, None, 1 147456 mixed6[0][0]

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conv2d\_63 (Conv2D) (None, None, None, 1 258048 activation\_62[0][0]

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conv2d\_68 (Conv2D) (None, None, None, 1 258048 activation\_67[0][0]

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conv2d\_69 (Conv2D) (None, None, None, 1 147456 average\_pooling2d\_6[0][0]

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batch\_normalization\_60 (BatchNo (None, None, None, 1 576 conv2d\_60[0][0]

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batch\_normalization\_63 (BatchNo (None, None, None, 1 576 conv2d\_63[0][0]

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batch\_normalization\_68 (BatchNo (None, None, None, 1 576 conv2d\_68[0][0]

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batch\_normalization\_69 (BatchNo (None, None, None, 1 576 conv2d\_69[0][0]

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activation\_60 (Activation) (None, None, None, 1 0 batch\_normalization\_60[0][0]

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activation\_63 (Activation) (None, None, None, 1 0 batch\_normalization\_63[0][0]

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activation\_68 (Activation) (None, None, None, 1 0 batch\_normalization\_68[0][0]

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activation\_69 (Activation) (None, None, None, 1 0 batch\_normalization\_69[0][0]

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mixed7 (Concatenate) (None, None, None, 7 0 activation\_60[0][0]

activation\_63[0][0]

activation\_68[0][0]

activation\_69[0][0]

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conv2d\_72 (Conv2D) (None, None, None, 1 147456 mixed7[0][0]

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batch\_normalization\_72 (BatchNo (None, None, None, 1 576 conv2d\_72[0][0]

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activation\_72 (Activation) (None, None, None, 1 0 batch\_normalization\_72[0][0]

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conv2d\_73 (Conv2D) (None, None, None, 1 258048 activation\_72[0][0]

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batch\_normalization\_73 (BatchNo (None, None, None, 1 576 conv2d\_73[0][0]

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activation\_73 (Activation) (None, None, None, 1 0 batch\_normalization\_73[0][0]

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conv2d\_70 (Conv2D) (None, None, None, 1 147456 mixed7[0][0]

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conv2d\_74 (Conv2D) (None, None, None, 1 258048 activation\_73[0][0]

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batch\_normalization\_70 (BatchNo (None, None, None, 1 576 conv2d\_70[0][0]

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batch\_normalization\_74 (BatchNo (None, None, None, 1 576 conv2d\_74[0][0]

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activation\_70 (Activation) (None, None, None, 1 0 batch\_normalization\_70[0][0]

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activation\_74 (Activation) (None, None, None, 1 0 batch\_normalization\_74[0][0]

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conv2d\_71 (Conv2D) (None, None, None, 3 552960 activation\_70[0][0]

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conv2d\_75 (Conv2D) (None, None, None, 1 331776 activation\_74[0][0]

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batch\_normalization\_71 (BatchNo (None, None, None, 3 960 conv2d\_71[0][0]

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batch\_normalization\_75 (BatchNo (None, None, None, 1 576 conv2d\_75[0][0]

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activation\_71 (Activation) (None, None, None, 3 0 batch\_normalization\_71[0][0]

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activation\_75 (Activation) (None, None, None, 1 0 batch\_normalization\_75[0][0]

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max\_pooling2d\_3 (MaxPooling2D) (None, None, None, 7 0 mixed7[0][0]

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mixed8 (Concatenate) (None, None, None, 1 0 activation\_71[0][0]

activation\_75[0][0]

max\_pooling2d\_3[0][0]

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conv2d\_80 (Conv2D) (None, None, None, 4 573440 mixed8[0][0]

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batch\_normalization\_80 (BatchNo (None, None, None, 4 1344 conv2d\_80[0][0]

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activation\_80 (Activation) (None, None, None, 4 0 batch\_normalization\_80[0][0]

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conv2d\_77 (Conv2D) (None, None, None, 3 491520 mixed8[0][0]

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conv2d\_81 (Conv2D) (None, None, None, 3 1548288 activation\_80[0][0]

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batch\_normalization\_77 (BatchNo (None, None, None, 3 1152 conv2d\_77[0][0]

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batch\_normalization\_81 (BatchNo (None, None, None, 3 1152 conv2d\_81[0][0]

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activation\_77 (Activation) (None, None, None, 3 0 batch\_normalization\_77[0][0]

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activation\_81 (Activation) (None, None, None, 3 0 batch\_normalization\_81[0][0]

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conv2d\_78 (Conv2D) (None, None, None, 3 442368 activation\_77[0][0]

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conv2d\_79 (Conv2D) (None, None, None, 3 442368 activation\_77[0][0]

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conv2d\_82 (Conv2D) (None, None, None, 3 442368 activation\_81[0][0]

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conv2d\_83 (Conv2D) (None, None, None, 3 442368 activation\_81[0][0]

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average\_pooling2d\_7 (AveragePoo (None, None, None, 1 0 mixed8[0][0]

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conv2d\_76 (Conv2D) (None, None, None, 3 409600 mixed8[0][0]

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batch\_normalization\_78 (BatchNo (None, None, None, 3 1152 conv2d\_78[0][0]

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batch\_normalization\_79 (BatchNo (None, None, None, 3 1152 conv2d\_79[0][0]

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batch\_normalization\_82 (BatchNo (None, None, None, 3 1152 conv2d\_82[0][0]

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batch\_normalization\_83 (BatchNo (None, None, None, 3 1152 conv2d\_83[0][0]

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conv2d\_84 (Conv2D) (None, None, None, 1 245760 average\_pooling2d\_7[0][0]

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batch\_normalization\_76 (BatchNo (None, None, None, 3 960 conv2d\_76[0][0]

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activation\_78 (Activation) (None, None, None, 3 0 batch\_normalization\_78[0][0]

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activation\_79 (Activation) (None, None, None, 3 0 batch\_normalization\_79[0][0]

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activation\_82 (Activation) (None, None, None, 3 0 batch\_normalization\_82[0][0]

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activation\_83 (Activation) (None, None, None, 3 0 batch\_normalization\_83[0][0]

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batch\_normalization\_84 (BatchNo (None, None, None, 1 576 conv2d\_84[0][0]

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activation\_76 (Activation) (None, None, None, 3 0 batch\_normalization\_76[0][0]

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mixed9\_0 (Concatenate) (None, None, None, 7 0 activation\_78[0][0]

activation\_79[0][0]

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concatenate (Concatenate) (None, None, None, 7 0 activation\_82[0][0]

activation\_83[0][0]

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activation\_84 (Activation) (None, None, None, 1 0 batch\_normalization\_84[0][0]

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mixed9 (Concatenate) (None, None, None, 2 0 activation\_76[0][0]

mixed9\_0[0][0]

concatenate[0][0]

activation\_84[0][0]

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conv2d\_89 (Conv2D) (None, None, None, 4 917504 mixed9[0][0]

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batch\_normalization\_89 (BatchNo (None, None, None, 4 1344 conv2d\_89[0][0]

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activation\_89 (Activation) (None, None, None, 4 0 batch\_normalization\_89[0][0]

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conv2d\_86 (Conv2D) (None, None, None, 3 786432 mixed9[0][0]

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conv2d\_90 (Conv2D) (None, None, None, 3 1548288 activation\_89[0][0]

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batch\_normalization\_86 (BatchNo (None, None, None, 3 1152 conv2d\_86[0][0]

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batch\_normalization\_90 (BatchNo (None, None, None, 3 1152 conv2d\_90[0][0]

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activation\_86 (Activation) (None, None, None, 3 0 batch\_normalization\_86[0][0]

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activation\_90 (Activation) (None, None, None, 3 0 batch\_normalization\_90[0][0]

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conv2d\_87 (Conv2D) (None, None, None, 3 442368 activation\_86[0][0]

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conv2d\_88 (Conv2D) (None, None, None, 3 442368 activation\_86[0][0]

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conv2d\_91 (Conv2D) (None, None, None, 3 442368 activation\_90[0][0]

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conv2d\_92 (Conv2D) (None, None, None, 3 442368 activation\_90[0][0]

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average\_pooling2d\_8 (AveragePoo (None, None, None, 2 0 mixed9[0][0]

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conv2d\_85 (Conv2D) (None, None, None, 3 655360 mixed9[0][0]

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batch\_normalization\_87 (BatchNo (None, None, None, 3 1152 conv2d\_87[0][0]

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batch\_normalization\_88 (BatchNo (None, None, None, 3 1152 conv2d\_88[0][0]

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batch\_normalization\_91 (BatchNo (None, None, None, 3 1152 conv2d\_91[0][0]

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batch\_normalization\_92 (BatchNo (None, None, None, 3 1152 conv2d\_92[0][0]

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conv2d\_93 (Conv2D) (None, None, None, 1 393216 average\_pooling2d\_8[0][0]

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batch\_normalization\_85 (BatchNo (None, None, None, 3 960 conv2d\_85[0][0]

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activation\_87 (Activation) (None, None, None, 3 0 batch\_normalization\_87[0][0]

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activation\_88 (Activation) (None, None, None, 3 0 batch\_normalization\_88[0][0]

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activation\_91 (Activation) (None, None, None, 3 0 batch\_normalization\_91[0][0]

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activation\_92 (Activation) (None, None, None, 3 0 batch\_normalization\_92[0][0]

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batch\_normalization\_93 (BatchNo (None, None, None, 1 576 conv2d\_93[0][0]

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activation\_85 (Activation) (None, None, None, 3 0 batch\_normalization\_85[0][0]

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mixed9\_1 (Concatenate) (None, None, None, 7 0 activation\_87[0][0]

activation\_88[0][0]

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concatenate\_1 (Concatenate) (None, None, None, 7 0 activation\_91[0][0]

activation\_92[0][0]

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activation\_93 (Activation) (None, None, None, 1 0 batch\_normalization\_93[0][0]

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mixed10 (Concatenate) (None, None, None, 2 0 activation\_85[0][0]

mixed9\_1[0][0]

concatenate\_1[0][0]

activation\_93[0][0]

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decoder\_stage0\_upsampling (UpSa (None, None, None, 2 0 mixed10[0][0]

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decoder\_stage0\_concat (Concaten (None, None, None, 2 0 decoder\_stage0\_upsampling[0][0]

mixed7[0][0]

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decoder\_stage0a\_conv (Conv2D) (None, None, None, 2 6488064 decoder\_stage0\_concat[0][0]

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decoder\_stage0a\_bn (BatchNormal (None, None, None, 2 1024 decoder\_stage0a\_conv[0][0]

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decoder\_stage0a\_relu (Activatio (None, None, None, 2 0 decoder\_stage0a\_bn[0][0]

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decoder\_stage0b\_conv (Conv2D) (None, None, None, 2 589824 decoder\_stage0a\_relu[0][0]

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decoder\_stage0b\_bn (BatchNormal (None, None, None, 2 1024 decoder\_stage0b\_conv[0][0]

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decoder\_stage0b\_relu (Activatio (None, None, None, 2 0 decoder\_stage0b\_bn[0][0]

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decoder\_stage1\_upsampling (UpSa (None, None, None, 2 0 decoder\_stage0b\_relu[0][0]

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decoder\_stage1\_concat (Concaten (None, None, None, 5 0 decoder\_stage1\_upsampling[0][0]

mixed2[0][0]

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decoder\_stage1a\_conv (Conv2D) (None, None, None, 1 626688 decoder\_stage1\_concat[0][0]

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decoder\_stage1a\_bn (BatchNormal (None, None, None, 1 512 decoder\_stage1a\_conv[0][0]

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decoder\_stage1a\_relu (Activatio (None, None, None, 1 0 decoder\_stage1a\_bn[0][0]

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decoder\_stage1b\_conv (Conv2D) (None, None, None, 1 147456 decoder\_stage1a\_relu[0][0]

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decoder\_stage1b\_bn (BatchNormal (None, None, None, 1 512 decoder\_stage1b\_conv[0][0]

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decoder\_stage1b\_relu (Activatio (None, None, None, 1 0 decoder\_stage1b\_bn[0][0]

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decoder\_stage2\_upsampling (UpSa (None, None, None, 1 0 decoder\_stage1b\_relu[0][0]

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decoder\_stage2\_concat (Concaten (None, None, None, 3 0 decoder\_stage2\_upsampling[0][0]

activation\_4[0][0]

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decoder\_stage2a\_conv (Conv2D) (None, None, None, 6 184320 decoder\_stage2\_concat[0][0]

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decoder\_stage2a\_bn (BatchNormal (None, None, None, 6 256 decoder\_stage2a\_conv[0][0]

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decoder\_stage2a\_relu (Activatio (None, None, None, 6 0 decoder\_stage2a\_bn[0][0]

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decoder\_stage2b\_conv (Conv2D) (None, None, None, 6 36864 decoder\_stage2a\_relu[0][0]

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decoder\_stage2b\_bn (BatchNormal (None, None, None, 6 256 decoder\_stage2b\_conv[0][0]

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decoder\_stage2b\_relu (Activatio (None, None, None, 6 0 decoder\_stage2b\_bn[0][0]

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decoder\_stage3\_upsampling (UpSa (None, None, None, 6 0 decoder\_stage2b\_relu[0][0]

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decoder\_stage3\_concat (Concaten (None, None, None, 1 0 decoder\_stage3\_upsampling[0][0]

activation\_2[0][0]

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decoder\_stage3a\_conv (Conv2D) (None, None, None, 3 36864 decoder\_stage3\_concat[0][0]

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decoder\_stage3a\_bn (BatchNormal (None, None, None, 3 128 decoder\_stage3a\_conv[0][0]

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decoder\_stage3a\_relu (Activatio (None, None, None, 3 0 decoder\_stage3a\_bn[0][0]

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decoder\_stage3b\_conv (Conv2D) (None, None, None, 3 9216 decoder\_stage3a\_relu[0][0]

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decoder\_stage3b\_bn (BatchNormal (None, None, None, 3 128 decoder\_stage3b\_conv[0][0]

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decoder\_stage3b\_relu (Activatio (None, None, None, 3 0 decoder\_stage3b\_bn[0][0]

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decoder\_stage4\_upsampling (UpSa (None, None, None, 3 0 decoder\_stage3b\_relu[0][0]

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decoder\_stage4a\_conv (Conv2D) (None, None, None, 1 4608 decoder\_stage4\_upsampling[0][0]

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decoder\_stage4a\_bn (BatchNormal (None, None, None, 1 64 decoder\_stage4a\_conv[0][0]

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decoder\_stage4a\_relu (Activatio (None, None, None, 1 0 decoder\_stage4a\_bn[0][0]

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decoder\_stage4b\_conv (Conv2D) (None, None, None, 1 2304 decoder\_stage4a\_relu[0][0]

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decoder\_stage4b\_bn (BatchNormal (None, None, None, 1 64 decoder\_stage4b\_conv[0][0]

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decoder\_stage4b\_relu (Activatio (None, None, None, 1 0 decoder\_stage4b\_bn[0][0]

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final\_conv (Conv2D) (None, None, None, 2 290 decoder\_stage4b\_relu[0][0]

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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

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

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Layer (type) Output Shape Param # Connected to

==================================================================================================

input\_1 (InputLayer) [(None, None, None, 0

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block1\_conv1 (Conv2D) (None, None, None, 6 1792 input\_1[0][0]

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block1\_conv2 (Conv2D) (None, None, None, 6 36928 block1\_conv1[0][0]

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block1\_pool (MaxPooling2D) (None, None, None, 6 0 block1\_conv2[0][0]

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block2\_conv1 (Conv2D) (None, None, None, 1 73856 block1\_pool[0][0]

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block2\_conv2 (Conv2D) (None, None, None, 1 147584 block2\_conv1[0][0]

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block2\_pool (MaxPooling2D) (None, None, None, 1 0 block2\_conv2[0][0]

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block3\_conv1 (Conv2D) (None, None, None, 2 295168 block2\_pool[0][0]

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block3\_conv2 (Conv2D) (None, None, None, 2 590080 block3\_conv1[0][0]

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block3\_conv3 (Conv2D) (None, None, None, 2 590080 block3\_conv2[0][0]

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block3\_pool (MaxPooling2D) (None, None, None, 2 0 block3\_conv3[0][0]

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block4\_conv1 (Conv2D) (None, None, None, 5 1180160 block3\_pool[0][0]

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block4\_conv2 (Conv2D) (None, None, None, 5 2359808 block4\_conv1[0][0]

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block4\_conv3 (Conv2D) (None, None, None, 5 2359808 block4\_conv2[0][0]

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block4\_pool (MaxPooling2D) (None, None, None, 5 0 block4\_conv3[0][0]

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block5\_conv1 (Conv2D) (None, None, None, 5 2359808 block4\_pool[0][0]

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block5\_conv2 (Conv2D) (None, None, None, 5 2359808 block5\_conv1[0][0]

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block5\_conv3 (Conv2D) (None, None, None, 5 2359808 block5\_conv2[0][0]

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block5\_pool (MaxPooling2D) (None, None, None, 5 0 block5\_conv3[0][0]

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center\_block1\_conv (Conv2D) (None, None, None, 5 2359296 block5\_pool[0][0]

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center\_block1\_bn (BatchNormaliz (None, None, None, 5 2048 center\_block1\_conv[0][0]

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center\_block1\_relu (Activation) (None, None, None, 5 0 center\_block1\_bn[0][0]

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center\_block2\_conv (Conv2D) (None, None, None, 5 2359296 center\_block1\_relu[0][0]

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center\_block2\_bn (BatchNormaliz (None, None, None, 5 2048 center\_block2\_conv[0][0]

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center\_block2\_relu (Activation) (None, None, None, 5 0 center\_block2\_bn[0][0]

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decoder\_stage0\_upsampling (UpSa (None, None, None, 5 0 center\_block2\_relu[0][0]

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decoder\_stage0\_concat (Concaten (None, None, None, 1 0 decoder\_stage0\_upsampling[0][0]

block5\_conv3[0][0]

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decoder\_stage0a\_conv (Conv2D) (None, None, None, 2 2359296 decoder\_stage0\_concat[0][0]

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decoder\_stage0a\_bn (BatchNormal (None, None, None, 2 1024 decoder\_stage0a\_conv[0][0]

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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]

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decoder\_stage0b\_bn (BatchNormal (None, None, None, 2 1024 decoder\_stage0b\_conv[0][0]

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decoder\_stage0b\_relu (Activatio (None, None, None, 2 0 decoder\_stage0b\_bn[0][0]

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decoder\_stage1\_upsampling (UpSa (None, None, None, 2 0 decoder\_stage0b\_relu[0][0]

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decoder\_stage1\_concat (Concaten (None, None, None, 7 0 decoder\_stage1\_upsampling[0][0]

block4\_conv3[0][0]

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decoder\_stage1a\_conv (Conv2D) (None, None, None, 1 884736 decoder\_stage1\_concat[0][0]

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decoder\_stage1a\_bn (BatchNormal (None, None, None, 1 512 decoder\_stage1a\_conv[0][0]

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decoder\_stage1a\_relu (Activatio (None, None, None, 1 0 decoder\_stage1a\_bn[0][0]

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decoder\_stage1b\_conv (Conv2D) (None, None, None, 1 147456 decoder\_stage1a\_relu[0][0]

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decoder\_stage1b\_bn (BatchNormal (None, None, None, 1 512 decoder\_stage1b\_conv[0][0]

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decoder\_stage1b\_relu (Activatio (None, None, None, 1 0 decoder\_stage1b\_bn[0][0]

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decoder\_stage2\_upsampling (UpSa (None, None, None, 1 0 decoder\_stage1b\_relu[0][0]

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decoder\_stage2\_concat (Concaten (None, None, None, 3 0 decoder\_stage2\_upsampling[0][0]

block3\_conv3[0][0]

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decoder\_stage2a\_conv (Conv2D) (None, None, None, 6 221184 decoder\_stage2\_concat[0][0]

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decoder\_stage2a\_bn (BatchNormal (None, None, None, 6 256 decoder\_stage2a\_conv[0][0]

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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]

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decoder\_stage2b\_bn (BatchNormal (None, None, None, 6 256 decoder\_stage2b\_conv[0][0]

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decoder\_stage2b\_relu (Activatio (None, None, None, 6 0 decoder\_stage2b\_bn[0][0]

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decoder\_stage3\_upsampling (UpSa (None, None, None, 6 0 decoder\_stage2b\_relu[0][0]

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decoder\_stage3\_concat (Concaten (None, None, None, 1 0 decoder\_stage3\_upsampling[0][0]

block2\_conv2[0][0]

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decoder\_stage3a\_conv (Conv2D) (None, None, None, 3 55296 decoder\_stage3\_concat[0][0]

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decoder\_stage3a\_bn (BatchNormal (None, None, None, 3 128 decoder\_stage3a\_conv[0][0]

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decoder\_stage3a\_relu (Activatio (None, None, None, 3 0 decoder\_stage3a\_bn[0][0]

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decoder\_stage3b\_conv (Conv2D) (None, None, None, 3 9216 decoder\_stage3a\_relu[0][0]

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decoder\_stage3b\_bn (BatchNormal (None, None, None, 3 128 decoder\_stage3b\_conv[0][0]

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decoder\_stage3b\_relu (Activatio (None, None, None, 3 0 decoder\_stage3b\_bn[0][0]

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decoder\_stage4\_upsampling (UpSa (None, None, None, 3 0 decoder\_stage3b\_relu[0][0]

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decoder\_stage4a\_conv (Conv2D) (None, None, None, 1 4608 decoder\_stage4\_upsampling[0][0]

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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]

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decoder\_stage4b\_conv (Conv2D) (None, None, None, 1 2304 decoder\_stage4a\_relu[0][0]

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decoder\_stage4b\_bn (BatchNormal (None, None, None, 1 64 decoder\_stage4b\_conv[0][0]

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decoder\_stage4b\_relu (Activatio (None, None, None, 1 0 decoder\_stage4b\_bn[0][0]

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final\_conv (Conv2D) (None, None, None, 2 290 decoder\_stage4b\_relu[0][0]

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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

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None