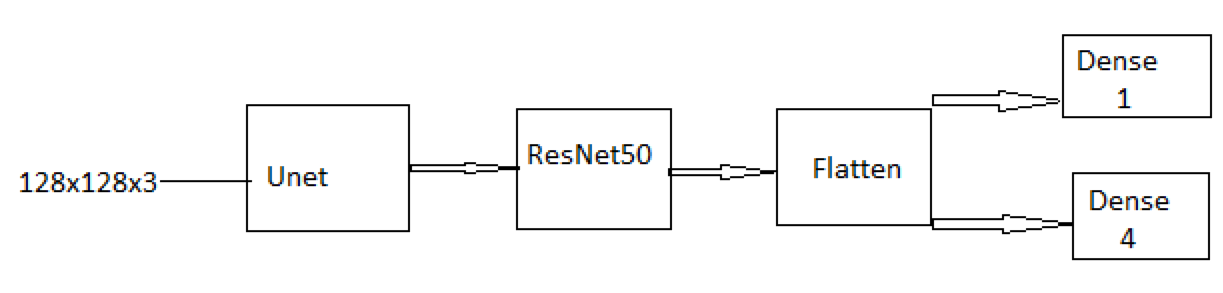
Summary of Transfer learning using UNET and ResNet

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The model was built with Unet model trained with Pneumonia dataset at the input side

And sequentially connected to the Keras inbuilt ResNet model.



ResNet is used Mostly in order to solve a complex problem, we stack some additional layers in the Deep Neural Networks which results in improved accuracy and performance. The intuition behind adding more layers is that these layers progressively learn more complex features,

Also ResNet is a proven model which helps to tackle the vanishing gradient problem by using skip connections between layers, and it was proven to have very less error rate.

To implement ResNet version1 with 50 layers (**ResNet 50**), we simply use the function from Keras a

tf.keras.applications.ResNet50(

include\_top=True,

weights="imagenet",

input\_tensor=None,

input\_shape=None,

pooling=None,

classes=1000,

\*\*kwargs

)

**Arguments**

* **include\_top**: whether to include the fully-connected layer at the top of the network.
* **weights**: one of None (random initialization), ‘Imagenet’ (pre-training on ImageNet), or the path to the weights file to be loaded.
* **input\_tensor**: optional Keras tensor (i.e. output of layers.Input()) to use as image input for the model.
* **input\_shape**: optional shape tuple, only to be specified if include\_top is False (otherwise the input shape has to be (224, 224, 3) (with ‘channels\_last’ data format) or (3, 224, 224) (with ‘channels\_first’ data format). It should have exactly 3 inputs channels, and width and height should be no smaller than 32. E.g. (200, 200, 3) would be one valid value.
* **pooling**: Optional pooling mode for feature extraction when include\_top is False.
  + None means that the output of the model will be the 4D tensor output of the last convolutional block.
  + avg means that global average pooling will be applied to the output of the last convolutional block, and thus the output of the model will be a 2D tensor.
  + max means that global max pooling will be applied.
* **classes**: optional number of classes to classify images into, only to be specified if include\_top is True, and if no weights argument is specified.

**UNET: "model"**

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Layer (type) Output Shape Param # Connected to

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

input\_img (InputLayer) [(None, 128, 128, 3) 0

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conv2d (Conv2D) (None, 128, 128, 16) 448 input\_img[0][0]

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batch\_normalization (BatchNorma (None, 128, 128, 16) 64 conv2d[0][0]

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activation (Activation) (None, 128, 128, 16) 0 batch\_normalization[0][0]

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conv2d\_1 (Conv2D) (None, 128, 128, 16) 2320 activation[0][0]

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batch\_normalization\_1 (BatchNor (None, 128, 128, 16) 64 conv2d\_1[0][0]

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activation\_1 (Activation) (None, 128, 128, 16) 0 batch\_normalization\_1[0][0]

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max\_pooling2d (MaxPooling2D) (None, 64, 64, 16) 0 activation\_1[0][0]

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dropout (Dropout) (None, 64, 64, 16) 0 max\_pooling2d[0][0]

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conv2d\_2 (Conv2D) (None, 64, 64, 32) 4640 dropout[0][0]

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batch\_normalization\_2 (BatchNor (None, 64, 64, 32) 128 conv2d\_2[0][0]

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activation\_2 (Activation) (None, 64, 64, 32) 0 batch\_normalization\_2[0][0]

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conv2d\_3 (Conv2D) (None, 64, 64, 32) 9248 activation\_2[0][0]

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batch\_normalization\_3 (BatchNor (None, 64, 64, 32) 128 conv2d\_3[0][0]

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activation\_3 (Activation) (None, 64, 64, 32) 0 batch\_normalization\_3[0][0]

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max\_pooling2d\_1 (MaxPooling2D) (None, 32, 32, 32) 0 activation\_3[0][0]

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dropout\_1 (Dropout) (None, 32, 32, 32) 0 max\_pooling2d\_1[0][0]

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conv2d\_4 (Conv2D) (None, 32, 32, 64) 18496 dropout\_1[0][0]

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batch\_normalization\_4 (BatchNor (None, 32, 32, 64) 256 conv2d\_4[0][0]

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activation\_4 (Activation) (None, 32, 32, 64) 0 batch\_normalization\_4[0][0]

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conv2d\_5 (Conv2D) (None, 32, 32, 64) 36928 activation\_4[0][0]

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batch\_normalization\_5 (BatchNor (None, 32, 32, 64) 256 conv2d\_5[0][0]

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activation\_5 (Activation) (None, 32, 32, 64) 0 batch\_normalization\_5[0][0]

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max\_pooling2d\_2 (MaxPooling2D) (None, 16, 16, 64) 0 activation\_5[0][0]

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dropout\_2 (Dropout) (None, 16, 16, 64) 0 max\_pooling2d\_2[0][0]

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conv2d\_6 (Conv2D) (None, 16, 16, 128) 73856 dropout\_2[0][0]

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batch\_normalization\_6 (BatchNor (None, 16, 16, 128) 512 conv2d\_6[0][0]

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activation\_6 (Activation) (None, 16, 16, 128) 0 batch\_normalization\_6[0][0]

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conv2d\_7 (Conv2D) (None, 16, 16, 128) 147584 activation\_6[0][0]

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batch\_normalization\_7 (BatchNor (None, 16, 16, 128) 512 conv2d\_7[0][0]

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activation\_7 (Activation) (None, 16, 16, 128) 0 batch\_normalization\_7[0][0]

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max\_pooling2d\_3 (MaxPooling2D) (None, 8, 8, 128) 0 activation\_7[0][0]

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dropout\_3 (Dropout) (None, 8, 8, 128) 0 max\_pooling2d\_3[0][0]

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conv2d\_8 (Conv2D) (None, 8, 8, 256) 295168 dropout\_3[0][0]

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batch\_normalization\_8 (BatchNor (None, 8, 8, 256) 1024 conv2d\_8[0][0]

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activation\_8 (Activation) (None, 8, 8, 256) 0 batch\_normalization\_8[0][0]

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conv2d\_9 (Conv2D) (None, 8, 8, 256) 590080 activation\_8[0][0]

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batch\_normalization\_9 (BatchNor (None, 8, 8, 256) 1024 conv2d\_9[0][0]

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activation\_9 (Activation) (None, 8, 8, 256) 0 batch\_normalization\_9[0][0]

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conv2d\_transpose (Conv2DTranspo (None, 16, 16, 128) 295040 activation\_9[0][0]

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concatenate (Concatenate) (None, 16, 16, 256) 0 conv2d\_transpose[0][0]

activation\_7[0][0]

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dropout\_4 (Dropout) (None, 16, 16, 256) 0 concatenate[0][0]

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conv2d\_10 (Conv2D) (None, 16, 16, 128) 295040 dropout\_4[0][0]

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batch\_normalization\_10 (BatchNo (None, 16, 16, 128) 512 conv2d\_10[0][0]

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activation\_10 (Activation) (None, 16, 16, 128) 0 batch\_normalization\_10[0][0]

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conv2d\_11 (Conv2D) (None, 16, 16, 128) 147584 activation\_10[0][0]

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batch\_normalization\_11 (BatchNo (None, 16, 16, 128) 512 conv2d\_11[0][0]

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activation\_11 (Activation) (None, 16, 16, 128) 0 batch\_normalization\_11[0][0]

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conv2d\_transpose\_1 (Conv2DTrans (None, 32, 32, 64) 73792 activation\_11[0][0]

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concatenate\_1 (Concatenate) (None, 32, 32, 128) 0 conv2d\_transpose\_1[0][0]

activation\_5[0][0]

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dropout\_5 (Dropout) (None, 32, 32, 128) 0 concatenate\_1[0][0]

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conv2d\_12 (Conv2D) (None, 32, 32, 64) 73792 dropout\_5[0][0]

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batch\_normalization\_12 (BatchNo (None, 32, 32, 64) 256 conv2d\_12[0][0]

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activation\_12 (Activation) (None, 32, 32, 64) 0 batch\_normalization\_12[0][0]

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conv2d\_13 (Conv2D) (None, 32, 32, 64) 36928 activation\_12[0][0]

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batch\_normalization\_13 (BatchNo (None, 32, 32, 64) 256 conv2d\_13[0][0]

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activation\_13 (Activation) (None, 32, 32, 64) 0 batch\_normalization\_13[0][0]

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conv2d\_transpose\_2 (Conv2DTrans (None, 64, 64, 32) 18464 activation\_13[0][0]

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concatenate\_2 (Concatenate) (None, 64, 64, 64) 0 conv2d\_transpose\_2[0][0]

activation\_3[0][0]

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dropout\_6 (Dropout) (None, 64, 64, 64) 0 concatenate\_2[0][0]

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conv2d\_14 (Conv2D) (None, 64, 64, 32) 18464 dropout\_6[0][0]

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batch\_normalization\_14 (BatchNo (None, 64, 64, 32) 128 conv2d\_14[0][0]

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activation\_14 (Activation) (None, 64, 64, 32) 0 batch\_normalization\_14[0][0]

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conv2d\_15 (Conv2D) (None, 64, 64, 32) 9248 activation\_14[0][0]

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batch\_normalization\_15 (BatchNo (None, 64, 64, 32) 128 conv2d\_15[0][0]

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activation\_15 (Activation) (None, 64, 64, 32) 0 batch\_normalization\_15[0][0]

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conv2d\_transpose\_3 (Conv2DTrans (None, 128, 128, 16) 4624 activation\_15[0][0]

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concatenate\_3 (Concatenate) (None, 128, 128, 32) 0 conv2d\_transpose\_3[0][0]

activation\_1[0][0]

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dropout\_7 (Dropout) (None, 128, 128, 32) 0 concatenate\_3[0][0]

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conv2d\_16 (Conv2D) (None, 128, 128, 16) 4624 dropout\_7[0][0]

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batch\_normalization\_16 (BatchNo (None, 128, 128, 16) 64 conv2d\_16[0][0]

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activation\_16 (Activation) (None, 128, 128, 16) 0 batch\_normalization\_16[0][0]

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conv2d\_17 (Conv2D) (None, 128, 128, 16) 2320 activation\_16[0][0]

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batch\_normalization\_17 (BatchNo (None, 128, 128, 16) 64 conv2d\_17[0][0]

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activation\_17 (Activation) (None, 128, 128, 16) 0 batch\_normalization\_17[0][0]

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**global\_average\_pooling2d (Globa (None, 16) 0 activation\_17[0][0]**

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**class\_op (Dense) (None, 1) 17 global\_average\_pooling2d[0][0]**

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**reg\_op (Dense) (None, 4) 68 global\_average\_pooling2d[0][0]**

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Total params: 2,164,661

Trainable params: 2,161,717

Non-trainable params: 2,944

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We can see that from the summary Inorder to connect the UNET model to Resnet model

We had to remove the output layers of the Unet model which were a Flattening layer which internally connected to classification and Regression Dense layers.

After removing these layers we could not just connect the UNET model directly to the ResNet50 model input, as UNET is a functional layer and we do not have to model.add api in the functional model.

So to connect these models we had to write the below code

from keras.models import Model

#removing the output layer from the pretrained unet model

prev\_model = keras.models.Model(UnetModel\_v1.input, UnetModel\_v1.layers[-4].output)

Unet\_transfer\_model = Sequential()

Unet\_transfer\_model.add(prev\_model)

Unet\_transfer\_model.add(tf.keras.applications.ResNet50(input\_shape= (image\_size, image\_size, 16), include\_top=False, weights=None))

Unet\_transfer\_model.add(tf.keras.layers.GlobalAveragePooling2D())

#Global average pool to reduce number of features and Flatten the output

#Classification output

label\_output = tf.keras.layers.Dense(1,

activation='sigmoid',

name='class\_op')(last\_layer)

#Regression

bbox\_output = tf.keras.layers.Dense(4,

activation='sigmoid',

name='reg\_op')(last\_layer)

Unet\_transfer\_model = tf.keras.models.Model(inputs=Unet\_transfer\_model.input, #Pre-trained model input as input layer

outputs=[label\_output,bbox\_output]) #Output layer added

We can see that it's not allowed to directly connect Unet model output to ResNet model as we cannot connect Functional and Sequential models directly.

So we had to create a sequential model , then add the Unet layers and ResNet model.

**Final model:**

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Layer (type) Output Shape Param # Connected to

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

model\_input (InputLayer) [(None, 128, 128, 3) 0

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model (Functional) (None, 128, 128, 16) 2164576 model\_input[0][0]

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resnet50 (Functional) (None, 4, 4, 2048) 23628480 model[0][0]

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global\_average\_pooling2d (Globa (None, 2048) 0 resnet50[0][0]

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class\_op (Dense) (None, 1) 2049 global\_average\_pooling2d[0][0]

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reg\_op (Dense) (None, 4) 8196 global\_average\_pooling2d[0][0]

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Total params: 25,803,301

Trainable params: 23,585,605

Non-trainable params: 2,217,696

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We can see that he Trainable parameters of UNET Model are set to false as we have already trained them with Pneumonia detection Dataset

UNET model has around 2 million weights compared to 25 million weights from ResNet

**INPUT:**

* The Input for our model will be an image array of 128x128x3

**Output:**

* Same as for Our vgg model

**Loss Function:**

* Same as for Our vgg model

**Metrics:**

* Same as for Our vgg model

**Train and Validation sets:**

* Same as for Our vgg model

**Image Augmentation:**

* Same as for Our vgg model

**Result**:

* With all these steps we fit the model and ran it for 100 epochs and obtained the below accuracy for classification and regression.
  + Train Iou => , Validation Iou =>
  + Train\_accuracy => , Validation accuracy =>