Face Mask Prediction using U-Net

Mounting Google drive for using google colab

In [ ]:

```
from google.colab import drive
drive.mount('/content/drive/')
```

```
Drive already mounted at /content/drive/; to attempt to forcibly remount, call
drive.mount("/content/drive/", force_remount=True).
```

Loading "images.npy" file

In [ ]:

```
import numpy as np
import cv2
from tensorflow.keras.applications.mobilenet import preprocess_input
from sklearn.model_selection import train_test_split
import matplotlib.pyplot as plt
from tensorflow.keras.applications.mobilenet import MobileNet
from tensorflow.keras.layers import Reshape, UpSampling2D, Concatenate, Conv2D,Activation, BatchNormalization, SpatialDropout2D
from tensorflow.keras.models import Model
from tensorflow.keras.optimizers import Adam
from tensorflow.keras.losses import binary_crossentropy
from tensorflow.keras.callbacks import ModelCheckpoint, EarlyStopping, ReduceLROnPlateau
from tensorflow.keras.backend import log, epsilon
import tensorflow as tf
```

In [ ]:

```
data =np.load('/content/drive/My Drive/Colab Notebooks/images.npy',allow_pickle=True)
```

Checking one sample from the loaded "images.npy" file

In [ ]:

```
 print(data[10][1])
```

```
[{'label': ['Face'], 'notes': '', 'points': [{'x': 0.48, 'y': 0.10385756676557864}, {'x':
0.7716666666666666, 'y': 0.6795252225519288}], 'imageWidth': 600, 'imageHeight': 337}]
```

Setting image dimensions

- Initializing image height, image width with value: 224

In [ ]:

```
ALPHA = 1
IMAGE_HEIGHT = 224
IMAGE_WIDTH = 224
IMAGE_SIZE = 224
HEIGHT_CELLS = 28
WIDTH_CELLS = 28
```

Create features and labels

In [ ]:

```
masks = np.zeros((int(data.shape[0]), IMAGE_HEIGHT, IMAGE_WIDTH))
X = np.zeros((int(data.shape[0]), IMAGE_HEIGHT, IMAGE_WIDTH, 3))
for index in range(data.shape[0]):
    img = data[index][0]
    img = cv2.resize(img, dsize=(IMAGE_HEIGHT, IMAGE_WIDTH), interpolation=cv2.INTER_CUBIC)
    try:
      img = img[:, :, :3]
    except:
      continue
    X[index] = preprocess_input(np.array(img, dtype=np.float32))
    for i in data[index][1]:
        x1 = int(i["points"][0]['x'] * IMAGE_WIDTH)
        x2 = int(i["points"][1]['x'] * IMAGE_WIDTH)
        y1 = int(i["points"][0]['y'] * IMAGE_HEIGHT)
        y2 = int(i["points"][1]['y'] * IMAGE_HEIGHT)
        masks[index][y1:y2, x1:x2] = 1
```

Splitting the data into training and testing

- 400 images in training
- 9 images in testing data

In [ ]:

```
X_train, X_test, y_train, y_test = train_test_split(X,masks, test_size=0.02, random_state=0)
```

Shape of training and testing data

In [ ]:

```
X_train.shape
```

Out[ ]:

```
(400, 224, 224, 3)
```

In [ ]:

```
y_train.shape
```

Out[ ]:

```
(400, 224, 224)
```

In [ ]:

```
y_test.shape
```

Out[ ]:

```
(9, 224, 224)
```

In [ ]:

```
X_test.shape
```

Out[ ]:

```
(9, 224, 224, 3)
```

Print a sample training image, image array and its mask

Print the image and image array

Print the image and image array

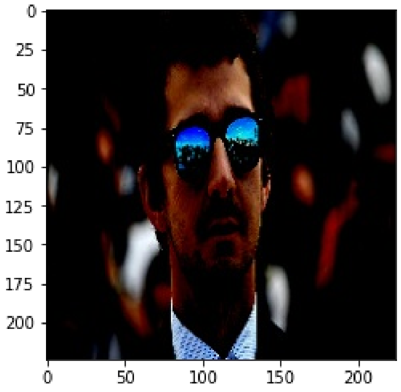
In [ ]:

```
plt.imshow(X_train[1])
```

```
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers).
```

Out[ ]:

```
<matplotlib.image.AxesImage at 0x7f86167071d0>
```



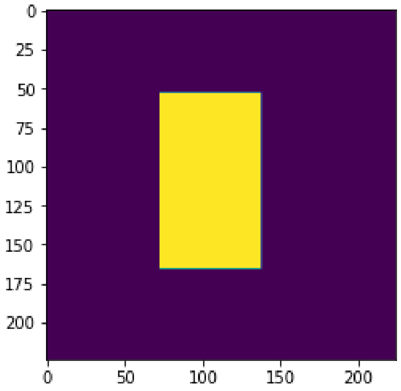
Print the mask

In [ ]:

```
plt.imshow(y_train[1])
```

Out[ ]:

```
<matplotlib.image.AxesImage at 0x7f861676a160>
```



Creating the model

- Adding MobileNet as model with below parameter values
  - input_shape: IMAGE_HEIGHT, IMAGE_WIDTH, 3
  - include_top: False
  - alpha: 1.0
  - weights: "imagenet"
- Adding UNET architecture layers

In [ ]:

```
def conv_block_simple(prevlayer, filters, prefix, strides=(1, 1)):
    conv = Conv2D(filters, (3, 3), padding = 'same', kernel_initializer = 'he_normal', strides = strides, name = prefix + '_conv')(prevlayer)
    conv = BatchNormalization(name = prefix + 'BatchNormalization')(conv)
    conv = BatchNormalization(name = prefix + 'BatchNormalization')(conv)
    conv = Activation('relu', name = prefix + 'ActivationLayer')(conv)
    return conv

def create_model(trainable = True):
    model = MobileNet(input_shape = (IMAGE_HEIGHT, IMAGE_WIDTH, 3), include_top = False, alpha = AL
PHA, weights = 'imagenet')
    for layer in model.layers:
        layer.trainable = trainable

    block1 = model.get_layer('conv_pw_13_relu').output
    block2 = model.get_layer('conv_pw_11_relu').output
    block3 = model.get_layer('conv_pw_5_relu').output
    block4 = model.get_layer('conv_pw_3_relu').output
    block5 = model.get_layer('conv_pw_1_relu').output

    up1 = Concatenate()([UpSampling2D()(block1), block2])
    conv6 = conv_block_simple(up1, 256, 'Conv_6_1')
    conv6 = conv_block_simple(conv6, 256, 'Conv_6_2')

    up2 = Concatenate()([UpSampling2D()(conv6), block3])
    conv7 = conv_block_simple(up2, 256, 'Conv_7_1')
    conv7 = conv_block_simple(conv7, 256, 'Conv_7_2')

    up3 = Concatenate()([UpSampling2D()(conv7), block4])
    conv8 = conv_block_simple(up3, 192, 'Conv_8_1')
    conv8 = conv_block_simple(conv8, 128, 'Conv_8_2')

    up4 = Concatenate()([UpSampling2D()(conv8), block5])
    conv9 = conv_block_simple(up4, 96, 'Conv_9_1')
    conv9 = conv_block_simple(conv9, 64, 'Conv_9_2')

    up5 = Concatenate()([UpSampling2D()(conv9), model.input])
    conv10 = conv_block_simple(up5, 48, 'Conv_10_1')
    conv10 = conv_block_simple(conv10, 32, 'Conv_10_2')
    conv10 = SpatialDropout2D(0.2)(conv10)

    x = Conv2D(1, (1, 1), activation = 'sigmoid')(conv10)
    x = Reshape((IMAGE_SIZE, IMAGE_SIZE))(x)
    return Model(inputs = model.input, outputs = x)
```

Calling the create_model function

- Giving trainable=False as argument

In [ ]:

```
model = create_model(False)
```

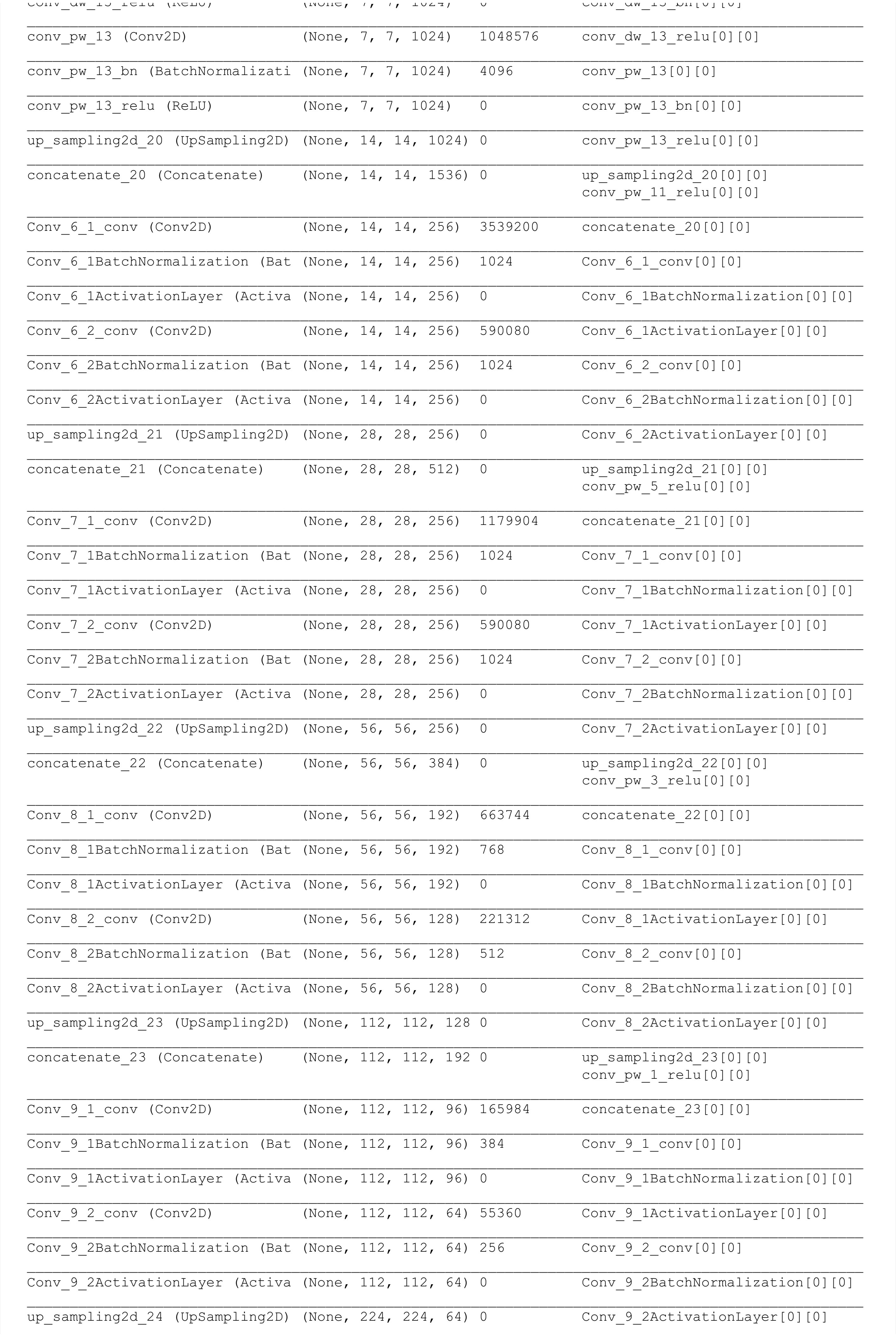
Model summary

In [ ]:

```
model.summary()
```

```
Model: "functional_9"
__________________________________________________________________________________________________
Layer (type)                    Output Shape         Param #     Connected to
==================================================================================================
input_5 (InputLayer)            [(None, 224, 224, 3) 0
__________________________________________________________________________________________________
conv1_pad (ZeroPadding2D)       (None, 225, 225, 3)  0           input_5[0][0]
__________________________________________________________________________________________________
conv1 (Conv2D)                  (None, 112, 112, 32) 864         conv1_pad[0][0]
__________________________________________________________________________________________________
conv1_bn (BatchNormalization)   (None, 112, 112, 32) 128         conv1[0][0]
__________________________________________________________________________________________________
conv1_relu (ReLU)               (None, 112, 112, 32) 0           conv1_bn[0][0]
__________________________________________________________________________________________________
conv_dw_1 (DepthwiseConv2D)     (None, 112, 112, 32) 288         conv1_relu[0][0]
__________________________________________________________________________________________________
conv_dw_1_bn (BatchNormalizatio (None, 112, 112, 32) 128         conv_dw_1[0][0]
conv_dw_1_bn (BatchNormalizatio (None, 112, 112, 32) 128         conv_dw_1[0][0]
__________________________________________________________________________________________________
conv_dw_1_relu (ReLU)           (None, 112, 112, 32) 0           conv_dw_1_bn[0][0]
__________________________________________________________________________________________________
conv_pw_1 (Conv2D)              (None, 112, 112, 64) 2048        conv_dw_1_relu[0][0]
__________________________________________________________________________________________________
conv_pw_1_bn (BatchNormalizatio (None, 112, 112, 64) 256         conv_pw_1[0][0]
__________________________________________________________________________________________________
conv_pw_1_relu (ReLU)           (None, 112, 112, 64) 0           conv_pw_1_bn[0][0]
__________________________________________________________________________________________________
conv_pad_2 (ZeroPadding2D)      (None, 113, 113, 64) 0           conv_pw_1_relu[0][0]
__________________________________________________________________________________________________
conv_dw_2 (DepthwiseConv2D)     (None, 56, 56, 64)   576         conv_pad_2[0][0]
__________________________________________________________________________________________________
conv_dw_2_bn (BatchNormalizatio (None, 56, 56, 64)   256         conv_dw_2[0][0]
__________________________________________________________________________________________________
conv_dw_2_relu (ReLU)           (None, 56, 56, 64)   0           conv_dw_2_bn[0][0]
__________________________________________________________________________________________________
conv_pw_2 (Conv2D)              (None, 56, 56, 128)  8192        conv_dw_2_relu[0][0]
__________________________________________________________________________________________________
conv_pw_2_bn (BatchNormalizatio (None, 56, 56, 128)  512         conv_pw_2[0][0]
__________________________________________________________________________________________________
conv_pw_2_relu (ReLU)           (None, 56, 56, 128)  0           conv_pw_2_bn[0][0]
__________________________________________________________________________________________________
conv_dw_3 (DepthwiseConv2D)     (None, 56, 56, 128)  1152        conv_pw_2_relu[0][0]
__________________________________________________________________________________________________
conv_dw_3_bn (BatchNormalizatio (None, 56, 56, 128)  512         conv_dw_3[0][0]
__________________________________________________________________________________________________
conv_dw_3_relu (ReLU)           (None, 56, 56, 128)  0           conv_dw_3_bn[0][0]
__________________________________________________________________________________________________
conv_pw_3 (Conv2D)              (None, 56, 56, 128)  16384       conv_dw_3_relu[0][0]
__________________________________________________________________________________________________
conv_pw_3_bn (BatchNormalizatio (None, 56, 56, 128)  512         conv_pw_3[0][0]
__________________________________________________________________________________________________
conv_pw_3_relu (ReLU)           (None, 56, 56, 128)  0           conv_pw_3_bn[0][0]
__________________________________________________________________________________________________
conv_pad_4 (ZeroPadding2D)      (None, 57, 57, 128)  0           conv_pw_3_relu[0][0]
__________________________________________________________________________________________________
conv_dw_4 (DepthwiseConv2D)     (None, 28, 28, 128)  1152        conv_pad_4[0][0]
__________________________________________________________________________________________________
conv_dw_4_bn (BatchNormalizatio (None, 28, 28, 128)  512         conv_dw_4[0][0]
__________________________________________________________________________________________________
conv_dw_4_relu (ReLU)           (None, 28, 28, 128)  0           conv_dw_4_bn[0][0]
__________________________________________________________________________________________________
conv_pw_4 (Conv2D)              (None, 28, 28, 256)  32768       conv_dw_4_relu[0][0]
__________________________________________________________________________________________________
conv_pw_4_bn (BatchNormalizatio (None, 28, 28, 256)  1024        conv_pw_4[0][0]
__________________________________________________________________________________________________
conv_pw_4_relu (ReLU)           (None, 28, 28, 256)  0           conv_pw_4_bn[0][0]
__________________________________________________________________________________________________
conv_dw_5 (DepthwiseConv2D)     (None, 28, 28, 256)  2304        conv_pw_4_relu[0][0]
__________________________________________________________________________________________________
conv_dw_5_bn (BatchNormalizatio (None, 28, 28, 256)  1024        conv_dw_5[0][0]
__________________________________________________________________________________________________
conv_dw_5_relu (ReLU)           (None, 28, 28, 256)  0           conv_dw_5_bn[0][0]
__________________________________________________________________________________________________
conv_pw_5 (Conv2D)              (None, 28, 28, 256)  65536       conv_dw_5_relu[0][0]
__________________________________________________________________________________________________
conv_pw_5_bn (BatchNormalizatio (None, 28, 28, 256)  1024        conv_pw_5[0][0]
__________________________________________________________________________________________________
conv_pw_5_relu (ReLU)           (None, 28, 28, 256)  0           conv_pw_5_bn[0][0]
__________________________________________________________________________________________________
conv_pad_6 (ZeroPadding2D)      (None, 29, 29, 256)  0           conv_pw_5_relu[0][0]
__________________________________________________________________________________________________
conv_dw_6 (DepthwiseConv2D)     (None, 14, 14, 256)  2304        conv_pad_6[0][0]
__________________________________________________________________________________________________
conv_dw_6_bn (BatchNormalizatio (None, 14, 14, 256)  1024        conv_dw_6[0][0]
__________________________________________________________________________________________________
conv_dw_6_relu (ReLU)           (None, 14, 14, 256)  0           conv_dw_6_bn[0][0]
__________________________________________________________________________________________________
conv_pw_6 (Conv2D)              (None, 14, 14, 512)  131072      conv_dw_6_relu[0][0]
__________________________________________________________________________________________________
conv_pw_6_bn (BatchNormalizatio (None, 14, 14, 512)  2048        conv_pw_6[0][0]
__________________________________________________________________________________________________
conv_pw_6_relu (ReLU)           (None, 14, 14, 512)  0           conv_pw_6_bn[0][0]
__________________________________________________________________________________________________
conv_dw_7 (DepthwiseConv2D)     (None, 14, 14, 512)  4608        conv_pw_6_relu[0][0]
```

```
__________________________________________________________________________________________________
conv_dw_7_bn (BatchNormalizatio (None, 14, 14, 512)   2048        conv_dw_7[0][0]
__________________________________________________________________________________________________
conv_dw_7_relu (ReLU)           (None, 14, 14, 512)   0           conv_dw_7_bn[0][0]
__________________________________________________________________________________________________
conv_pw_7 (Conv2D)              (None, 14, 14, 512)   262144      conv_dw_7_relu[0][0]
__________________________________________________________________________________________________
conv_pw_7_bn (BatchNormalizatio (None, 14, 14, 512)   2048        conv_pw_7[0][0]
__________________________________________________________________________________________________
conv_pw_7_relu (ReLU)           (None, 14, 14, 512)   0           conv_pw_7_bn[0][0]
__________________________________________________________________________________________________
conv_dw_8 (DepthwiseConv2D)     (None, 14, 14, 512)   4608        conv_pw_7_relu[0][0]
__________________________________________________________________________________________________
conv_dw_8_bn (BatchNormalizatio (None, 14, 14, 512)   2048        conv_dw_8[0][0]
__________________________________________________________________________________________________
conv_dw_8_relu (ReLU)           (None, 14, 14, 512)   0           conv_dw_8_bn[0][0]
__________________________________________________________________________________________________
conv_pw_8 (Conv2D)              (None, 14, 14, 512)   262144      conv_dw_8_relu[0][0]
__________________________________________________________________________________________________
conv_pw_8_bn (BatchNormalizatio (None, 14, 14, 512)   2048        conv_pw_8[0][0]
__________________________________________________________________________________________________
conv_pw_8_relu (ReLU)           (None, 14, 14, 512)   0           conv_pw_8_bn[0][0]
__________________________________________________________________________________________________
conv_dw_9 (DepthwiseConv2D)     (None, 14, 14, 512)   4608        conv_pw_8_relu[0][0]
__________________________________________________________________________________________________
conv_dw_9_bn (BatchNormalizatio (None, 14, 14, 512)   2048        conv_dw_9[0][0]
__________________________________________________________________________________________________
conv_dw_9_relu (ReLU)           (None, 14, 14, 512)   0           conv_dw_9_bn[0][0]
__________________________________________________________________________________________________
conv_pw_9 (Conv2D)              (None, 14, 14, 512)   262144      conv_dw_9_relu[0][0]
__________________________________________________________________________________________________
conv_pw_9_bn (BatchNormalizatio (None, 14, 14, 512)   2048        conv_pw_9[0][0]
__________________________________________________________________________________________________
conv_pw_9_relu (ReLU)           (None, 14, 14, 512)   0           conv_pw_9_bn[0][0]
__________________________________________________________________________________________________
conv_dw_10 (DepthwiseConv2D)    (None, 14, 14, 512)   4608        conv_pw_9_relu[0][0]
__________________________________________________________________________________________________
conv_dw_10_bn (BatchNormalizati (None, 14, 14, 512)   2048        conv_dw_10[0][0]
__________________________________________________________________________________________________
conv_dw_10_relu (ReLU)          (None, 14, 14, 512)   0           conv_dw_10_bn[0][0]
__________________________________________________________________________________________________
conv_pw_10 (Conv2D)             (None, 14, 14, 512)   262144      conv_dw_10_relu[0][0]
__________________________________________________________________________________________________
conv_pw_10_bn (BatchNormalizati (None, 14, 14, 512)   2048        conv_pw_10[0][0]
__________________________________________________________________________________________________
conv_pw_10_relu (ReLU)          (None, 14, 14, 512)   0           conv_pw_10_bn[0][0]
__________________________________________________________________________________________________
conv_dw_11 (DepthwiseConv2D)    (None, 14, 14, 512)   4608        conv_pw_10_relu[0][0]
__________________________________________________________________________________________________
conv_dw_11_bn (BatchNormalizati (None, 14, 14, 512)   2048        conv_dw_11[0][0]
__________________________________________________________________________________________________
conv_dw_11_relu (ReLU)          (None, 14, 14, 512)   0           conv_dw_11_bn[0][0]
__________________________________________________________________________________________________
conv_pw_11 (Conv2D)             (None, 14, 14, 512)   262144      conv_dw_11_relu[0][0]
__________________________________________________________________________________________________
conv_pw_11_bn (BatchNormalizati (None, 14, 14, 512)   2048        conv_pw_11[0][0]
__________________________________________________________________________________________________
conv_pw_11_relu (ReLU)          (None, 14, 14, 512)   0           conv_pw_11_bn[0][0]
__________________________________________________________________________________________________
conv_pad_12 (ZeroPadding2D)     (None, 15, 15, 512)   0           conv_pw_11_relu[0][0]
__________________________________________________________________________________________________
conv_dw_12 (DepthwiseConv2D)    (None, 7, 7, 512)     4608        conv_pad_12[0][0]
__________________________________________________________________________________________________
conv_dw_12_bn (BatchNormalizati (None, 7, 7, 512)     2048        conv_dw_12[0][0]
__________________________________________________________________________________________________
conv_dw_12_relu (ReLU)          (None, 7, 7, 512)     0           conv_dw_12_bn[0][0]
__________________________________________________________________________________________________
conv_pw_12 (Conv2D)             (None, 7, 7, 1024)    524288      conv_dw_12_relu[0][0]
__________________________________________________________________________________________________
conv_pw_12_bn (BatchNormalizati (None, 7, 7, 1024)    4096        conv_pw_12[0][0]
__________________________________________________________________________________________________
conv_pw_12_relu (ReLU)          (None, 7, 7, 1024)    0           conv_pw_12_bn[0][0]
__________________________________________________________________________________________________
conv_dw_13 (DepthwiseConv2D)    (None, 7, 7, 1024)    9216        conv_pw_12_relu[0][0]
__________________________________________________________________________________________________
conv_dw_13_bn (BatchNormalizati (None, 7, 7, 1024)    4096        conv_dw_13[0][0]
__________________________________________________________________________________________________
conv_dw_13_relu (ReLU)          (None, 7, 7, 1024)    0           conv_dw_13_bn[0][0]
```



```
conv_dw_13_relu (ReLU)          (None, 7, 7, 1024)   0           conv_dw_13_bn[0][0]
__________________________________________________________________________________________________
conv_pw_13 (Conv2D)             (None, 7, 7, 1024)   1048576     conv_dw_13_relu[0][0]
__________________________________________________________________________________________________
conv_pw_13_bn (BatchNormalizati (None, 7, 7, 1024)   4096        conv_pw_13[0][0]
__________________________________________________________________________________________________
conv_pw_13_relu (ReLU)          (None, 7, 7, 1024)   0           conv_pw_13_bn[0][0]
__________________________________________________________________________________________________
up_sampling2d_20 (UpSampling2D) (None, 14, 14, 1024) 0           conv_pw_13_relu[0][0]
__________________________________________________________________________________________________
concatenate_20 (Concatenate)    (None, 14, 14, 1536) 0           up_sampling2d_20[0][0]
                                                                 conv_pw_11_relu[0][0]
__________________________________________________________________________________________________
Conv_6_1_conv (Conv2D)          (None, 14, 14, 256)  3539200     concatenate_20[0][0]
__________________________________________________________________________________________________
Conv_6_1BatchNormalization (Bat (None, 14, 14, 256)  1024        Conv_6_1_conv[0][0]
__________________________________________________________________________________________________
Conv_6_1ActivationLayer (Activa (None, 14, 14, 256)  0           Conv_6_1BatchNormalization[0][0]
__________________________________________________________________________________________________
Conv_6_2_conv (Conv2D)          (None, 14, 14, 256)  590080      Conv_6_1ActivationLayer[0][0]
__________________________________________________________________________________________________
Conv_6_2BatchNormalization (Bat (None, 14, 14, 256)  1024        Conv_6_2_conv[0][0]
__________________________________________________________________________________________________
Conv_6_2ActivationLayer (Activa (None, 14, 14, 256)  0           Conv_6_2BatchNormalization[0][0]
__________________________________________________________________________________________________
up_sampling2d_21 (UpSampling2D) (None, 28, 28, 256)  0           Conv_6_2ActivationLayer[0][0]
__________________________________________________________________________________________________
concatenate_21 (Concatenate)    (None, 28, 28, 512)  0           up_sampling2d_21[0][0]
                                                                 conv_pw_5_relu[0][0]
__________________________________________________________________________________________________
Conv_7_1_conv (Conv2D)          (None, 28, 28, 256)  1179904     concatenate_21[0][0]
__________________________________________________________________________________________________
Conv_7_1BatchNormalization (Bat (None, 28, 28, 256)  1024        Conv_7_1_conv[0][0]
__________________________________________________________________________________________________
Conv_7_1ActivationLayer (Activa (None, 28, 28, 256)  0           Conv_7_1BatchNormalization[0][0]
__________________________________________________________________________________________________
Conv_7_2_conv (Conv2D)          (None, 28, 28, 256)  590080      Conv_7_1ActivationLayer[0][0]
__________________________________________________________________________________________________
Conv_7_2BatchNormalization (Bat (None, 28, 28, 256)  1024        Conv_7_2_conv[0][0]
__________________________________________________________________________________________________
Conv_7_2ActivationLayer (Activa (None, 28, 28, 256)  0           Conv_7_2BatchNormalization[0][0]
__________________________________________________________________________________________________
up_sampling2d_22 (UpSampling2D) (None, 56, 56, 256)  0           Conv_7_2ActivationLayer[0][0]
__________________________________________________________________________________________________
concatenate_22 (Concatenate)    (None, 56, 56, 384)  0           up_sampling2d_22[0][0]
                                                                 conv_pw_3_relu[0][0]
__________________________________________________________________________________________________
Conv_8_1_conv (Conv2D)          (None, 56, 56, 192)  663744      concatenate_22[0][0]
__________________________________________________________________________________________________
Conv_8_1BatchNormalization (Bat (None, 56, 56, 192)  768         Conv_8_1_conv[0][0]
__________________________________________________________________________________________________
Conv_8_1ActivationLayer (Activa (None, 56, 56, 192)  0           Conv_8_1BatchNormalization[0][0]
__________________________________________________________________________________________________
Conv_8_2_conv (Conv2D)          (None, 56, 56, 128)  221312      Conv_8_1ActivationLayer[0][0]
__________________________________________________________________________________________________
Conv_8_2BatchNormalization (Bat (None, 56, 56, 128)  512         Conv_8_2_conv[0][0]
__________________________________________________________________________________________________
Conv_8_2ActivationLayer (Activa (None, 56, 56, 128)  0           Conv_8_2BatchNormalization[0][0]
__________________________________________________________________________________________________
up_sampling2d_23 (UpSampling2D) (None, 112, 112, 128 0           Conv_8_2ActivationLayer[0][0]
__________________________________________________________________________________________________
concatenate_23 (Concatenate)    (None, 112, 112, 192 0           up_sampling2d_23[0][0]
                                                                 conv_pw_1_relu[0][0]
__________________________________________________________________________________________________
Conv_9_1_conv (Conv2D)          (None, 112, 112, 96) 165984      concatenate_23[0][0]
__________________________________________________________________________________________________
Conv_9_1BatchNormalization (Bat (None, 112, 112, 96) 384         Conv_9_1_conv[0][0]
__________________________________________________________________________________________________
Conv_9_1ActivationLayer (Activa (None, 112, 112, 96) 0           Conv_9_1BatchNormalization[0][0]
__________________________________________________________________________________________________
Conv_9_2_conv (Conv2D)          (None, 112, 112, 64) 55360       Conv_9_1ActivationLayer[0][0]
__________________________________________________________________________________________________
Conv_9_2BatchNormalization (Bat (None, 112, 112, 64) 256         Conv_9_2_conv[0][0]
__________________________________________________________________________________________________
Conv_9_2ActivationLayer (Activa (None, 112, 112, 64) 0           Conv_9_2BatchNormalization[0][0]
__________________________________________________________________________________________________
up_sampling2d_24 (UpSampling2D) (None, 224, 224, 64) 0           Conv_9_2ActivationLayer[0][0]
```

```
__________________________________________________________________________________________________
concatenate_24 (Concatenate)    (None, 224, 224, 67) 0           up_sampling2d_24[0][0]
                                                                 input_5[0][0]
__________________________________________________________________________________________________
Conv_10_1_conv (Conv2D)         (None, 224, 224, 48) 28992       concatenate_24[0][0]
__________________________________________________________________________________________________
Conv_10_1BatchNormalization (Ba (None, 224, 224, 48) 192         Conv_10_1_conv[0][0]
__________________________________________________________________________________________________
Conv_10_1ActivationLayer (Activ (None, 224, 224, 48) 0           Conv_10_1BatchNormalization[0][0]
__________________________________________________________________________________________________
Conv_10_2_conv (Conv2D)         (None, 224, 224, 32) 13856       Conv_10_1ActivationLayer[0][0]
__________________________________________________________________________________________________
Conv_10_2BatchNormalization (Ba (None, 224, 224, 32) 128         Conv_10_2_conv[0][0]
__________________________________________________________________________________________________
Conv_10_2ActivationLayer (Activ (None, 224, 224, 32) 0           Conv_10_2BatchNormalization[0][0]
__________________________________________________________________________________________________
spatial_dropout2d_4 (SpatialDro (None, 224, 224, 32) 0           Conv_10_2ActivationLayer[0][0]
__________________________________________________________________________________________________
conv2d_4 (Conv2D)               (None, 224, 224, 1)  33          spatial_dropout2d_4[0][0]
__________________________________________________________________________________________________
reshape_4 (Reshape)             (None, 224, 224)     0           conv2d_4[0][0]
==================================================================================================
Total params: 10,283,745
Trainable params: 7,051,713
Non-trainable params: 3,232,032
__________________________________________________________________________________________________
```

Defining dice coefficient function

In [ ]:

```
def dice_coefficient(y_true, y_pred):
    numerator = 2 * tf.reduce_sum(y_true * y_pred)
    denominator = tf.reduce_sum(y_true + y_pred)

    return numerator / (denominator + epsilon())
```

Defining loss function

In [ ]:

```
def loss(y_true, y_pred):
    return binary_crossentropy(y_true, y_pred) - log(dice_coefficient(y_true, y_pred) + epsilon())
```

Compiling the model

- Compliing the model using below parameters
  - loss: using the loss function defined above
  - optimizers: using Adam optimizer
  - metrics: using dice_coefficient function defined above

In [ ]:

```
optimizer = Adam(lr=1e-4, beta_1=0.9, beta_2=0.999, epsilon=None, decay=0.0, amsgrad=False)
model.compile(loss=loss, optimizer=optimizer, metrics=[dice_coefficient])
```

Defining callbacks

- Using ModelCheckpoint
- Using EarlyStopping
- Using ReduceLROnPlateau

In [ ]:

```
checkpoint = ModelCheckpoint("model-{val_loss:.2f}.h5", monitor="val_loss", verbose=1,
save_best_only=True, save_weights_only=True)
```

```
stop = EarlyStopping(monitor="val_loss", patience=5)

reduce_lr = ReduceLROnPlateau(monitor="val_loss", factor=0.2, patience=5, min_lr=1e-6, verbose=1)
```

Fitting the model

- Fitting the model using below parameters
  - epochs: 10
  - batch_size: 1
  - callbacks: using the callbacks defined above

In [ ]:

```
model.fit(X_train, y_train, epochs = 10, batch_size = 1, callbacks = [checkpoint, reduce_lr, stop],
validation_data = (X_test,y_test))
```

```
Epoch 1/10
  2/400 [..............................] - ETA: 17s - loss: 2.7443 - dice_coefficient:
0.1412WARNING:tensorflow:Callbacks method `on_train_batch_end` is slow compared to the batch time
(batch time: 0.0148s vs `on_train_batch_end` time: 0.0724s). Check your callbacks.
400/400 [==============================] - ETA: 0s - loss: 1.3733 - dice_coefficient:
0.4295WARNING:tensorflow:Callbacks method `on_test_batch_end` is slow compared to the batch time (
batch time: 0.0054s vs `on_test_batch_end` time: 0.0158s). Check your callbacks.

Epoch 00001: val_loss improved from inf to 0.93462, saving model to model-0.93.h5
400/400 [==============================] - 26s 65ms/step - loss: 1.3733 - dice_coefficient: 0.4295
- val_loss: 0.9346 - val_dice_coefficient: 0.5940
Epoch 2/10
400/400 [==============================] - ETA: 0s - loss: 0.9414 - dice_coefficient: 0.5445
Epoch 00002: val_loss improved from 0.93462 to 0.88956, saving model to model-0.89.h5
400/400 [==============================] - 26s 64ms/step - loss: 0.9414 - dice_coefficient: 0.5445
- val_loss: 0.8896 - val_dice_coefficient: 0.5494
Epoch 3/10
400/400 [==============================] - ETA: 0s - loss: 0.7281 - dice_coefficient: 0.6218
Epoch 00003: val_loss improved from 0.88956 to 0.75400, saving model to model-0.75.h5
400/400 [==============================] - 25s 63ms/step - loss: 0.7281 - dice_coefficient: 0.6218
- val_loss: 0.7540 - val_dice_coefficient: 0.6224
Epoch 4/10
400/400 [==============================] - ETA: 0s - loss: 0.5409 - dice_coefficient: 0.7009
Epoch 00004: val_loss did not improve from 0.75400
400/400 [==============================] - 25s 63ms/step - loss: 0.5409 - dice_coefficient: 0.7009
- val_loss: 0.7885 - val_dice_coefficient: 0.6292
Epoch 5/10
400/400 [==============================] - ETA: 0s - loss: 0.4265 - dice_coefficient: 0.7573
Epoch 00005: val_loss improved from 0.75400 to 0.73409, saving model to model-0.73.h5
400/400 [==============================] - 25s 63ms/step - loss: 0.4265 - dice_coefficient: 0.7573
- val_loss: 0.7341 - val_dice_coefficient: 0.6447
Epoch 6/10
400/400 [==============================] - ETA: 0s - loss: 0.3414 - dice_coefficient: 0.8043
Epoch 00006: val_loss did not improve from 0.73409
400/400 [==============================] - 25s 63ms/step - loss: 0.3414 - dice_coefficient: 0.8043
- val_loss: 0.9186 - val_dice_coefficient: 0.5871
Epoch 7/10
400/400 [==============================] - ETA: 0s - loss: 0.2959 - dice_coefficient: 0.8304
Epoch 00007: val_loss did not improve from 0.73409
400/400 [==============================] - 25s 63ms/step - loss: 0.2959 - dice_coefficient: 0.8304
- val_loss: 0.7356 - val_dice_coefficient: 0.6740
Epoch 8/10
400/400 [==============================] - ETA: 0s - loss: 0.2594 - dice_coefficient: 0.8520
Epoch 00008: val_loss did not improve from 0.73409
400/400 [==============================] - 25s 63ms/step - loss: 0.2594 - dice_coefficient: 0.8520
- val_loss: 0.8430 - val_dice_coefficient: 0.6313
Epoch 9/10
400/400 [==============================] - ETA: 0s - loss: 0.2284 - dice_coefficient: 0.8708
Epoch 00009: val_loss did not improve from 0.73409
400/400 [==============================] - 25s 63ms/step - loss: 0.2284 - dice_coefficient: 0.8708
- val_loss: 0.9912 - val_dice_coefficient: 0.5912
Epoch 10/10
400/400 [==============================] - ETA: 0s - loss: 0.1990 - dice_coefficient: 0.8905
Epoch 00010: val_loss did not improve from 0.73409

Epoch 00010: ReduceLROnPlateau reducing learning rate to 1.9999999494757503e-05.
```

```
400/400 [==============================] - 25s 63ms/step - loss: 0.1990 - dice_coefficient: 0.8905
- val_loss: 0.7871 - val_dice_coefficient: 0.6678
```

Out[ ]:

```
<tensorflow.python.keras.callbacks.History at 0x7f85b835db70>
```

In [ ]:

```
model.evaluate(X_test, y_test, verbose = 1)
```

```
1/1 [==============================] - 0s 2ms/step - loss: 0.7727 - dice_coefficient: 0.6681
```

Out[ ]:

```
[0.7726632356643677, 0.6680853962898254]
```

Getting the predicted mask for a test image

In [ ]:

```
WEIGHTS_FILE = "model-0.73.h5"
learned_model = create_model()
learned_model.load_weights(WEIGHTS_FILE)
y_pred = learned_model.predict(X_test, verbose = 1)
```

```
1/1 [==============================] - 0s 164ms/step
```

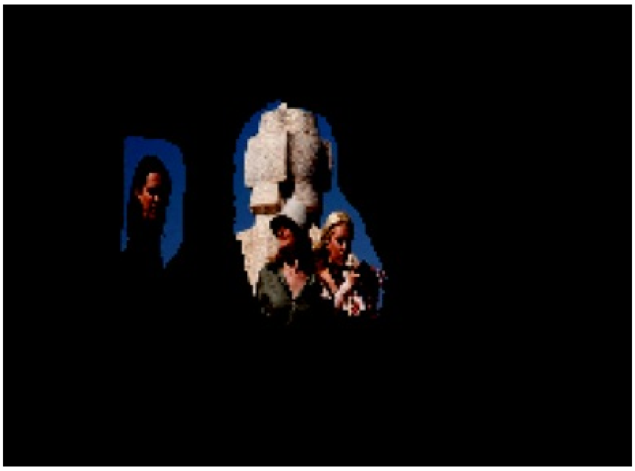
In [ ]:

```
n = 5
image = cv2.resize(X_test[n], dsize = (IMAGE_HEIGHT, IMAGE_WIDTH), interpolation = cv2.INTER_CUBIC)
pred_mask = cv2.resize(1.0*(y_pred[n] > 0.1), (IMAGE_WIDTH, IMAGE_HEIGHT))

image2 = image
image2[:,:,0] = pred_mask*image[:,:,0]
image2[:,:,1] = pred_mask*image[:,:,1]
image2[:,:,2] = pred_mask*image[:,:,2]
out_image = image2

fig = plt.figure(figsize = (15, 7.2))
ax = fig.add_subplot(1, 1, 1)
plt.axis('off')
plt.imshow(out_image)
```

```
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for
integers).
```

Out[ ]:

```
<matplotlib.image.AxesImage at 0x7f85b33f9978>
```

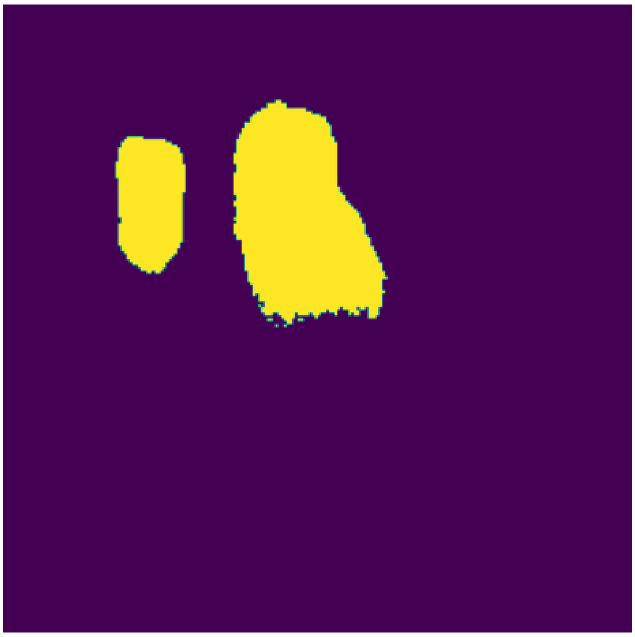


In [ ]:

```
fig = plt.figure(figsize = (15, 7.2))
ax = fig.add_subplot(1, 1, 1)
plt.axis('off')
plt.imshow(pred_mask, alpha = 1)
```

Out[ ]:

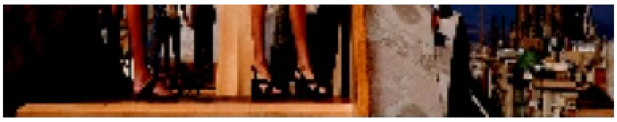
```
<matplotlib.image.AxesImage at 0x7f85b33f1320>
```



In [ ]:

```
fig = plt.figure(figsize = (10, 7))
ax = fig.add_subplot(1, 1, 1)
plt.axis('off')
plt.imshow(X_test[n])
plt.savefig('image1.jpg', bbox_inches = 'tight', pad_inches = 0)
```

```
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for
integers).
```

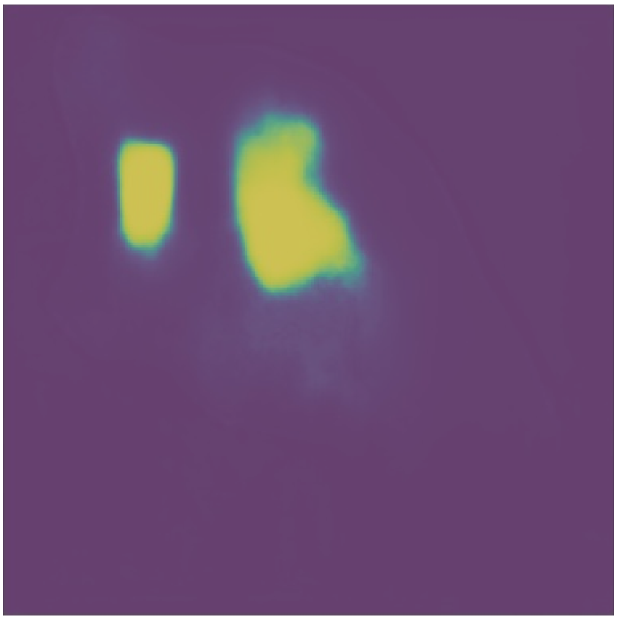


Imposing the mask on the test image

- In imshow using the alpha parameter and setting it to greater than 0.5

In [ ]:

```
fig = plt.figure(figsize = (10, 7))
ax = fig.add_subplot(1, 1, 1)
plt.axis('off')
plt.imshow(y_pred[n], alpha = 0.75)
plt.savefig('mask1.jpg', bbox_inches = 'tight', pad_inches = 0)
```



In [ ]:

```
from google.colab.patches import cv2_imshow
img = cv2.imread('image1.jpg', 1)
mask = cv2.imread('mask1.jpg', 1)
img = cv2.add(img, mask)
cv2_imshow(img)
```