

Phase02-Image tampering detection: Finding the exact tampered region using Image localization and better augmentation techniques

In the previous notebook, we have tried to classify whether an image is real or fake through Error Level Analysis using CASIA dataset. (Phase-01 of the Forensics challenge)

This is a rough implementation of phase-02 of the forensics challenge

In [1]:

```
# Import Libraries

import warnings
warnings.filterwarnings("ignore")

import matplotlib.pyplot as plt
import PIL
import numpy as np
import pandas as pd
import os
from PIL import Image
import matplotlib
from PIL import Image, ImageChops, ImageEnhance
from skimage.io import imread
from skimage import exposure, color
from skimage.transform import resize
from skimage.io import imread, imshow, concatenate_images
from skimage.transform import resize
from skimage.morphology import label
from itertools import chain
from sklearn.model_selection import train_test_split
import tensorflow as tf
import keras
from keras import backend as K
from keras.models import Sequential
from keras.layers import Dense, Dropout, Flatten

from keras.preprocessing.image import ImageDataGenerator
from keras.models import Model, load_model
from keras.layers import Input, BatchNormalization, Activation, Dense, Dropout
from keras.layers.core import Lambda, RepeatVector, Reshape

from keras.callbacks import EarlyStopping, ModelCheckpoint, ReduceLROnPlateau

from keras.optimizers import Adam, SGD
from keras import optimizers

from keras.preprocessing.image import ImageDataGenerator, array_to_img, img_to_array, load_img
from keras.models import load_model

from keras.applications.resnet import ResNet50
from keras.applications.resnet import ResNet101

from sklearn.metrics import roc_curve, auc, roc_auc_score

from tqdm import tqdm
import cv2
```

Using TensorFlow backend.

Image forgery localization is one of the most challenging tasks in digital image forensics. Different from forgery detection which simply discriminates whether a given image is pristine or fake, image forgery localization attempts to detect the accurate tampered areas.

In [2]:

```
path_original = '/home/ubuntu/Downloads/phase-01-training/dataset-dist/phase-01/training/pristine/'
path_tampered = '/home/ubuntu/Downloads/phase-01-training/dataset-dist/phase-01/training/fake/'
dataset_path = '/home/ubuntu/Downloads/phase-01-training/dataset-dist/phase-01/training/'
total_original = os.listdir(path_original)
total_tampered = os.listdir(path_tampered)
```

In [3]:

```
#https://stackoverflow.com/questions/47645115/oserror-cannot-identify-image-file-dataset-ds-store
total_tampered.remove('.DS_Store')
```

In [4]:

```
print('total number of pristine and tampered images are respectively:',len(total_original),',',len(total_tampered))
```

total number of pristine and tampered images are respectively: 1050 , 900

In [3]:

```
#saving the path along with the file names
pristine_images = []
for i in total_original:
    pristine_images.append(dataset_path+i)
fake_images = []
for i in total_tampered:
    fake_images.append(dataset_path+i)
```

In [4]:

```
total_tampered[0:5]
```

Out[4]:

```
['ae9dbc1d83a6063f921c7b6f19ecc468.png',
 'deb7cc4263e3dc9a640c57c7b2f714fd.png',
 'da87f75ad935467d3c8d0ab08a559e76.png',
 'd507e807f025f09ea0cff40b52e9322c.mask.png',
 'aa61a96b0a18b8dbc65fd20af3644958.mask.png']
```

In [5]:

```
def mask_pristine(path):
    img = Image.open(path).convert("RGB")
    img_shape=(np.array(img)).shape
    return np.ones((img_shape))*255

def plot_ground_truth_mask(image,fake=True):
    if fake:
        PATH=path_tampered+image.replace('.mask','')
    else:
        PATH=path_original+image

    PATH_mask=PATH[:-3]+'mask.png'

    img = Image.open(PATH).convert("RGB")

    try:
        mask_img=Image.open(PATH_mask).convert("RGB")
    except:
        mask_img=mask_pristine(PATH)
    fig = plt.figure(figsize=(15,10))
    ax1 = fig.add_subplot(221)
    ax2 = fig.add_subplot(222)
    ax1.set_title("Image")
    ax2.set_title("Ground Truth Mask")
    ax1.imshow(img)
    ax2.imshow(mask_img)
```

In [6]:

```
'd507e807f025f09ea0cff40b52e9322c.mask.png'.replace('.mask', '') [0:-4]
```

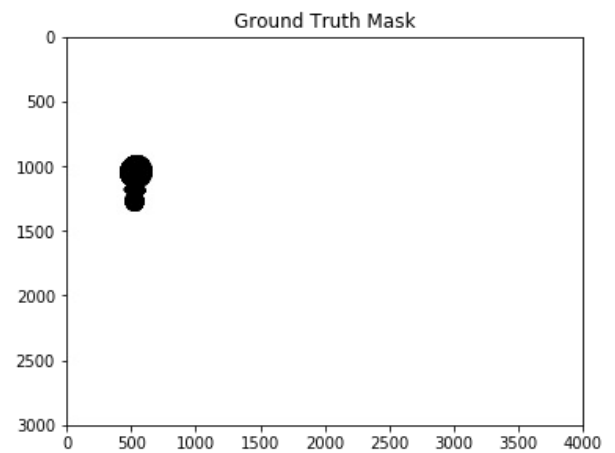
Out [6]:

```
'd507e807f025f09ea0cff40b52e9322c'
```

Tampered Image

In [7]:

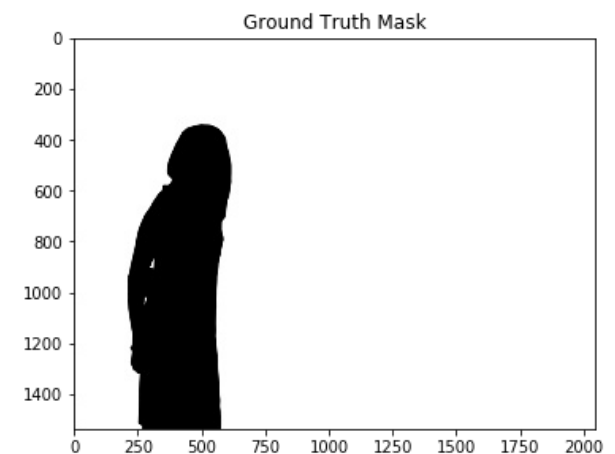
```
plot_ground_truth_mask(total_tampered[2])
```



- The clock on the wall is fake

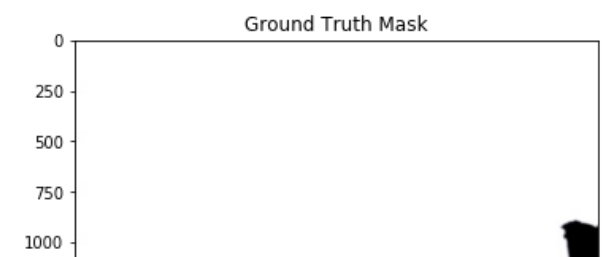
In [8]:

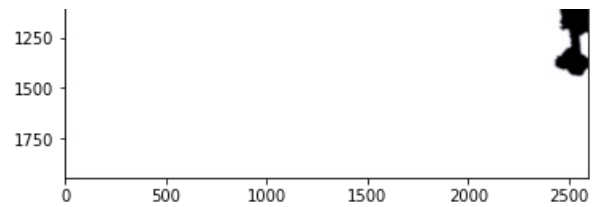
```
plot_ground_truth_mask(total_tampered[4])
```



In [10]:

```
plot_ground_truth_mask(total_tampered[7])
```





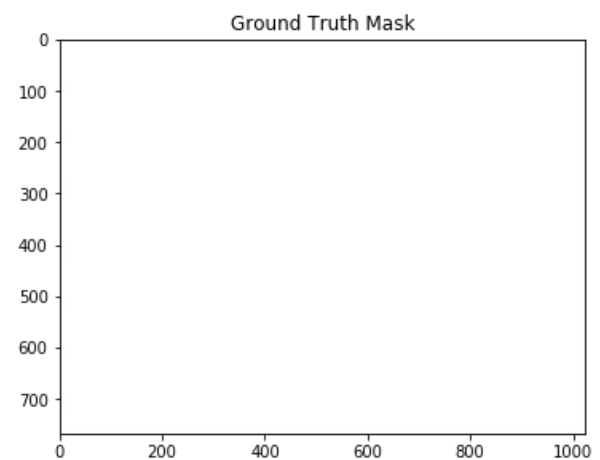
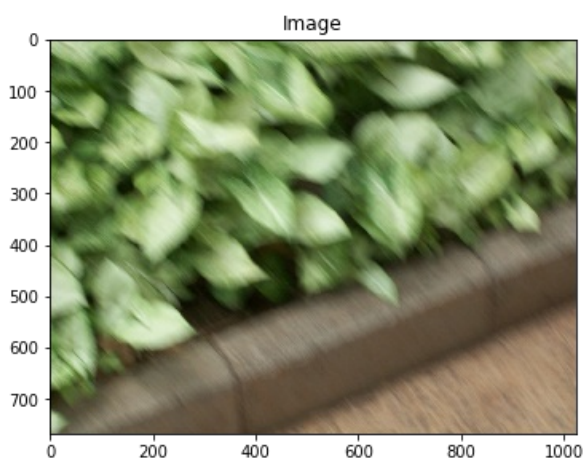
- So from the ground truth mask we get the portion of the image which got tampered.

Pristine Image

In [9]:

```
plot_ground_truth_mask(total_original[5], fake=False)
```

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



In [54]:

```
len(total_tampered)
```

Out[54]:

900

In [15]:

```
if not os.path.exists(dataset_path+"resized_images/"):
    os.makedirs(dataset_path+"resized_images/fake_masks/")
    os.makedirs(dataset_path+"resized_images/image/fake_images/")
    os.makedirs(dataset_path+"resized_images/image/pristine_images/")
    height = 512
    width = 512
    for fake_image in tqdm(total_tampered):
        if('.mask' in fake_image):
            img=Image.open(path_tampered + fake_image).convert("RGB")

            img = img.resize((height, width), PIL.Image.ANTIALIAS)
            img.save(dataset_path+"resized_images/fake_masks/"+fake_image)
        else:
            img=Image.open(path_tampered + fake_image).convert("RGB")

            img = img.resize((height, width), PIL.Image.ANTIALIAS)
            img.save(dataset_path+"resized_images/image/fake_images/"+fake_image)

    for pristine_image in tqdm(total_original):
```

```
img=Image.open(path_original + pristine_image).convert("RGB")

img = img.resize((height, width), PIL.Image.ANTIALIAS)
img.save(dataset_path+"resized_images/image/pristine_images/"+pristine_image)

else:
    print('images resized,path exists')
```

```
100%|██████████| 900/900 [01:25<00:00, 5.46it/s]
100%|██████████| 1050/1050 [01:50<00:00, 9.49it/s]
```

In [17]:

```
len(os.listdir(dataset_path+"resized_images/image/pristine_images/"))
```

Out[17]:

1050

In [23]:

```
resized_fakes = os.listdir(dataset_path+"resized_images/image/fake_images/")
```

In [25]:

```
resized_fake_path = dataset_path+"resized_images/image/fake_images/"
```

In [24]:

```
len(resized_fakes)
```

Out[24]:

450

In [18]:

```
#augmentation
```

Approaches used:

- Image Augmentation using albumentations module
- Find ELA of tampered image and convert it to array. This becomes the input X for training.
- Use the corresponding Ground Truth mask as the class label.
- The model will try to predict the tampered region using X and Y

Data Augmentation

- We want our CNN model to be robust to things like rotation, zoom, shift, shear and other operations on images.
- Since the number of images in the dataset provided to us is not sufficient enough, we make use of Image Augmentation to generate more data.

Data Augmentation using Albumentation Library

- citation link: <https://github.com/albumentations-team/albumentations#pypi>
- It is a fast image augmentation library and easy to use wrapper around other libraries

In [3]:

```
#pip install albumentations
```

Let's now get the ELA images our 512X512X3 images

Citation link: <https://researchweb.iiit.ac.in/~anurag.ghosh/static/detection-localization-image.pdf>

- Error Level Analysis: It works by intentionally resaving the JPEG image at a known error rate and then computing the difference between the images. Any modification to the picture will alter the image such that stable areas become unstable. Differently compressed versions of the image are compared with the possibly tampered one.
- ELA exploits the lossy compression of JPEG images. When an image is altered, the compression ratio of the specific portion changes with respect to other parts. <http://www.hackerfactor.com/papers/bh-usa-07-krawetz-wp.pdf>

Here's an amazing online tool you can use to understand how it works:

- <https://29a.ch/photo-forensics/#error-level-analysis>
- Click open file and experiment it with your own set of images

In []:

In []:

In [8]:

```
#https://gist.github.com/cirocosta/33c758ad77e6e6531392
#error level analysis of an image
def ELA(img_path):
    """Performs Error Level Analysis over a directory of images"""

    TEMP = 'ela_' + 'temp.jpg'
    SCALE = 10
    original = Image.open(img_path)
    try:
        original.save(TEMP, quality=90)
        temporary = Image.open(TEMP)
        diff = ImageChops.difference(original, temporary)

    except:

        original.convert('RGB').save(TEMP, quality=90)
        temporary = Image.open(TEMP)
        diff = ImageChops.difference(original.convert('RGB'), temporary)

    d = diff.load()

    WIDTH, HEIGHT = diff.size
    for x in range(WIDTH):
        for y in range(HEIGHT):
            d[x, y] = tuple(k * SCALE for k in d[x, y])
#     save_path = dataset_path + 'ELA_IMAGES/'
#     diff.save(save_path+'diff.png')
    return diff
```

In [26]:

```
if not os.path.exists(dataset_path+'ELA_IMAGES/'):
    os.makedirs(dataset_path+'ELA_IMAGES/')
    for i in tqdm(resized_fakes):
        ELA(resized_fake_path+i).save(dataset_path+'ELA_IMAGES/'+i)
else:
    print('Images are already converted to ELA')
```

```
100%|██████████| 450/450 [02:19<00:00, 3.14it/s]
```

In [31]:

```
#Files with the whole path:  
[dataset_path+"resized_images/fake_masks/"+i for i in  
os.listdir(dataset_path+"resized_images/fake_masks/") ][0:10]
```

Out[31]:

```
['/home/ubuntu/Downloads/phase-01-training/dataset-dist/phase-  
01/training/resized_images/fake_masks/d507e807f025f09ea0cff40b52e9322c.mask.png',  
 '/home/ubuntu/Downloads/phase-01-training/dataset-dist/phase-  
01/training/resized_images/fake_masks/aa61a96b0a18b8dbc65fd20af3644958.mask.png',  
 '/home/ubuntu/Downloads/phase-01-training/dataset-dist/phase-  
01/training/resized_images/fake_masks/a0942fb0a31b0f782d5d67a92e6f782c.mask.png',  
 '/home/ubuntu/Downloads/phase-01-training/dataset-dist/phase-  
01/training/resized_images/fake_masks/8330772517186ab2c21c9e80ddd3daf1.mask.png',  
 '/home/ubuntu/Downloads/phase-01-training/dataset-dist/phase-  
01/training/resized_images/fake_masks/ac23beb47b46fdc24e2f381be0aa6762.mask.png',  
 '/home/ubuntu/Downloads/phase-01-training/dataset-dist/phase-  
01/training/resized_images/fake_masks/a343124f546ea20b08092f6d2e72554f.mask.png',  
 '/home/ubuntu/Downloads/phase-01-training/dataset-dist/phase-  
01/training/resized_images/fake_masks/ce6a3e19dfcd8e8b162faf8511b920ae.mask.png',  
 '/home/ubuntu/Downloads/phase-01-training/dataset-dist/phase-  
01/training/resized_images/fake_masks/d4aff0ad5f4f99fc6cad4243b926eda7.mask.png',  
 '/home/ubuntu/Downloads/phase-01-training/dataset-dist/phase-  
01/training/resized_images/fake_masks/b3e198f58740cc8074ae1948efe7a1d2.mask.png',  
 '/home/ubuntu/Downloads/phase-01-training/dataset-dist/phase-  
01/training/resized_images/fake_masks/af4e76c3b9ef022cbffb9795592729ec.mask.png']
```

In [5]:

```
ELA_images_with_path = [dataset_path+'ELA_IMAGES/'+i for i in os.listdir(dataset_path+'ELA_IMAGES/'  
) ]  
fake_mask_with_path = [dataset_path+"resized_images/fake_masks/"+i for i in os.listdir(dataset_path  
+"resized_images/fake_masks/") ]
```

In [6]:

```
ELA_images_with_path.sort()
```

In [7]:

```
fake_mask_with_path.sort()
```

In [8]:

```
fake_mask_with_path[0]
```

Out[8]:

```
 '/home/ubuntu/Downloads/phase-01-training/dataset-dist/phase-  
01/training/resized_images/fake_masks/010543abfbd0db1e9aalb24604336e0c.mask.png'
```

In [9]:

```
ELA_images_with_path[0]
```

Out[9]:

```
 '/home/ubuntu/Downloads/phase-01-training/dataset-dist/phase-  
01/training/ELA_IMAGES/010543abfbd0db1e9aalb24604336e0c.png'
```

In [28]:

```
total_tampered.sort()
```

- 1000 -

In [29]:

```
total_tampered[0]
```

Out[29]:

```
'010543abfbd0db1e9aa1b24604336e0c.mask.png'
```

In [15]:

```
def ela_and_mask(index):  
  
    fig = plt.figure(figsize=(15,10))  
    ax1 = fig.add_subplot(331)  
    ax2 = fig.add_subplot(332)  
    ax3 = fig.add_subplot(333)  
    ax1.set_title("tampered")  
    ax2.set_title("ELA")  
    ax3.set_title("Ground Truth Mask")  
  
    ela_fake = Image.open(ELA_images_with_path[index])  
    fake_mask = Image.open(fake_mask_with_path[index])  
    tampered_image = Image.open(path_tampered+ELA_images_with_path[index][83:])  
    ax1.imshow(tampered_image)  
    ax2.imshow(ela_fake)  
    ax3.imshow(fake_mask)
```

In [85]:

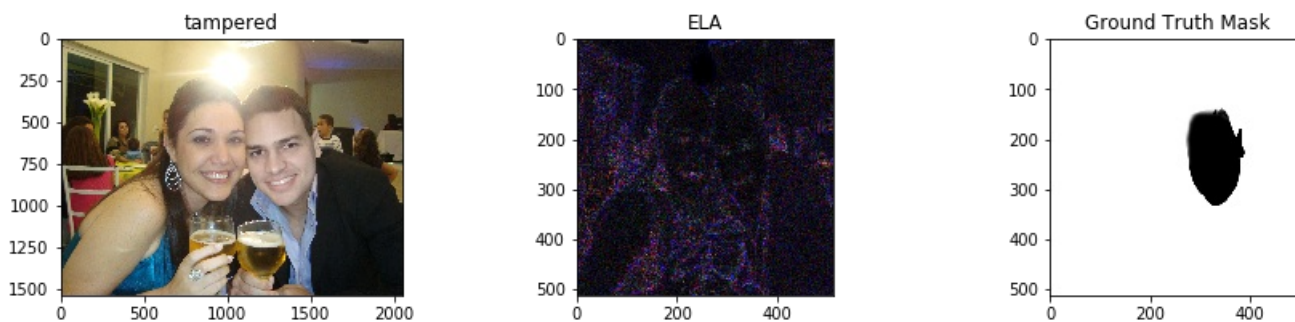
```
len('/home/ubuntu/Downloads/phase-01-training/dataset-dist/phase-01/training/ELA_IMAGES/')
```

Out[85]:

```
83
```

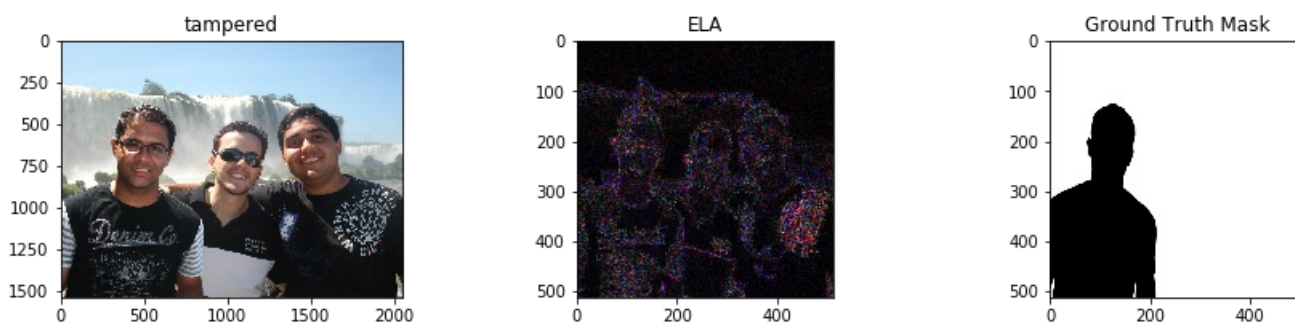
In [20]:

```
ela_and_mask(0)
```



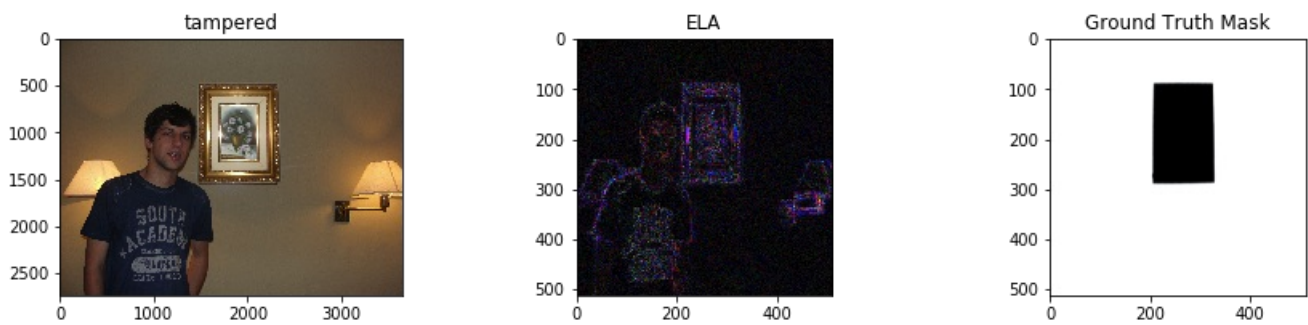
In [91]:

```
ela_and_mask(10)
```



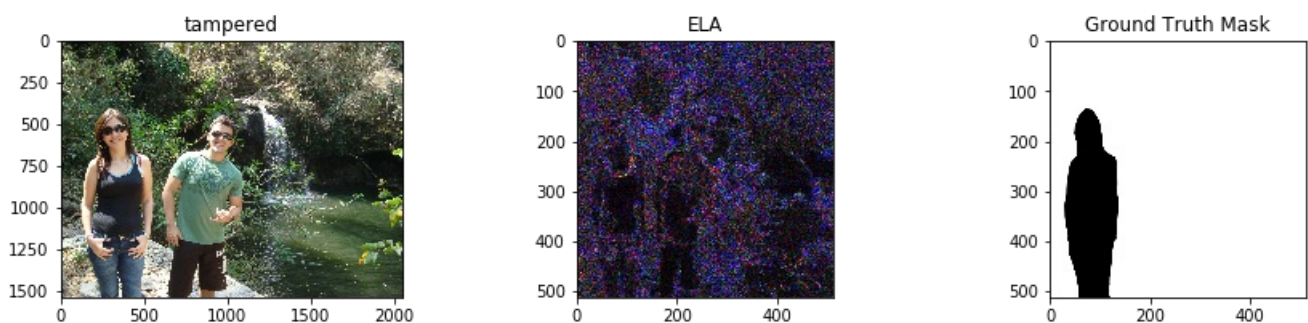
In [96]:

```
ela_and_mask(6)
```



In [30]:

```
ela_and_mask(45)
```



In [10]:

```
len(ELA_images_with_path), len(fake_mask_with_path)
```

Out[10]:

```
(450, 450)
```

In [11]:

```
X_train, X_val, Y_train, Y_val = train_test_split(ELA_images_with_path, fake_mask_with_path, test_size=0.12, random_state=7)
```

In [12]:

```
#citation: https://alumentations.readthedocs.io/en/latest/examples.html  
#https://github.com/alumentations-team/alumentations/blob/master/notebooks/example.ipynb
```

```
# the following code is copied directly from the documentation site :
```

```
## https://github.com/albu/alumentations
```

```
from alumentations import *
```

```
def strong_aug(p=1):  
    return Compose([  
        RandomRotate90(),  
  
        Transpose(),  
        OneOf([  
            IAAGaussianNoise(),  
            GaussNoise(),
```

```

    ], p=0.2),
    OneOf([
        MotionBlur(p=.2),
        MedianBlur(blur_limit=3, p=.1),
        Blur(blur_limit=3, p=.1),
    ], p=0.2),
    ShiftScaleRotate(shift_limit=0.0625, scale_limit=0.2, rotate_limit=45, p=.2),
    OneOf([
        OpticalDistortion(p=0.3),
        GridDistortion(p=.1),
        IAAPiecewiseAffine(p=0.3),
    ], p=0.2),
    OneOf([
        CLAHE(clip_limit=2),
        IAASharp(),
        IAAEmboss(),
        RandomContrast(),
    ], p=0.3),

], p=p)

def aug_with_crop(crop_prob = 1):
    return Compose([

        HorizontalFlip(p=0.5),
        VerticalFlip(p=0.5),
        RandomRotate90(p=0.5),
        Transpose(p=0.5),
        ShiftScaleRotate(shift_limit=0.01, scale_limit=0.04, rotate_limit=0, p=0.25),
        RandomBrightnessContrast(p=0.5),

        IAAEmboss(p=0.25),
        Blur(p=0.01, blur_limit = 3),
        OneOf([
            ElasticTransform(p=0.5, alpha=120, sigma=120 * 0.05, alpha_affine=120 * 0.03),
            GridDistortion(p=0.5),
            OpticalDistortion(p=1, distort_limit=2, shift_limit=0.5)
        ], p=0.8)
    ], p = 1)

def augment_flips_color(p=.5):
    return Compose([
        CLAHE(),
        RandomRotate90(),
        Transpose(),
        ShiftScaleRotate(shift_limit=0.0625, scale_limit=0.50, rotate_limit=45, p=.75),
        Blur(blur_limit=3),
        OpticalDistortion(),
        GridDistortion(),

    ], p=p)

def aug_data_1(p=.5):
    return Compose([
        CLAHE(),
        Transpose(),
        Blur(blur_limit=3),
        OpticalDistortion(),
        ElasticTransform(),
        HueSaturationValue()
    ], p=p)

def aug_data_2(p=.5):
    return Compose([
        CLAHE(),
        Blur(blur_limit=3),
        GridDistortion(),
        ElasticTransform(),
        HueSaturationValue()
    ], p=p)

```

In [33]:

X_val[45]

Out[33]:

```
'/home/ubuntu/Downloads/phase-01-training/dataset-dist/phase-01/training/ELA_IMAGES/a67721b7b84cb6e9649c67168d02274b.png'
```

In [15]:

```
def horizontalFlip(image,mask):
    aug = HorizontalFlip(p=1)
    augmented = aug(image=image, mask=mask)
    image_hflip = augmented['image']
    mask_hflip = augmented['mask']
    return image_hflip,mask_hflip

def verticalFlip(image,mask):
    aug = VerticalFlip(p=1)
    augmented = aug(image=image, mask=mask)
    image_vflip = augmented['image']
    mask_vflip = augmented['mask']
    return image_vflip,mask_vflip

def randomRotate(image,mask):
    aug = RandomRotate90(p=1)
    augmented = aug(image=image, mask=mask)
    image_rot90 = augmented['image']
    mask_rot90 = augmented['mask']
    return image_rot90,mask_rot90

def transpose(image,mask):
    aug = Transpose(p=1)
    augmented = aug(image=image, mask=mask)
    image_transpose = augmented['image']
    mask_transpose = augmented['mask']
    return image_transpose,mask_transpose

def elasticDistortion(image,mask):
    aug = ElasticTransform(p=1, alpha=120, sigma=120 * 0.05, alpha_affine=120 * 0.03)
    augmented = aug(image=image, mask=mask)
    image_ed = augmented['image']
    mask_ed = augmented['mask']
    return image_ed,mask_ed
```

In [35]:

```
Y_val[45]
```

Out[35]:

```
'/home/ubuntu/Downloads/phase-01-training/dataset-dist/phase-01/training/resized_images/fake_masks/a67721b7b84cb6e9649c67168d02274b.mask.png'
```

In [16]:

```
def opticalDistortion(image,mask):
    aug = OpticalDistortion(p=1, distort_limit=2, shift_limit=0.5)
    augmented = aug(image=image, mask=mask)
    image_od = augmented['image']
    mask_od = augmented['mask']
    return image_od,mask_od

def gridDistortion(image,mask):
    aug = GridDistortion()
    augmented = aug(image=image, mask=mask)
    image_od = augmented['image']
    mask_od = augmented['mask']
    return image_od,mask_od

def strong_Aug(image,mask):
    aug = strong_aug(p=1)
    augmented = aug(image=image, mask=mask)
    image_od = augmented['image']
    mask_od = augmented['mask']
    return image_od,mask_od
```

```

def aug_with_Crop(image,mask):
    aug = aug_with_crop()
    augmented = aug(image=image, mask=mask)
    image_od = augmented['image']
    mask_od = augmented['mask']
    return image_od,mask_od

def augment_flips_Color(image,mask):
    aug = augment_flips_color()
    image_od = aug(image=image) ['image']
    mask_od = aug(image=mask) ['image']

    return image_od,mask_od

def aug_Data_1(image,mask):
    aug = aug_data_1()

    image_od = aug(image=image) ['image']
    mask_od = aug(image=mask) ['image']

    return image_od,mask_od

def aug_Data_2(image,mask):
    aug = aug_data_2()

    image_od = aug(image=image) ['image']
    mask_od = aug(image=mask) ['image']

    return image_od,mask_od

```

In [17]:

```

def channelShuffle(image,mask):
    aug = ChannelShuffle(p=1)
    augmented = aug(image=image, mask=mask)
    image_od = augmented['image']
    mask_od = augmented['mask']
    return image_od,mask_od

def randomBrightness(image,mask):

    aug = RandomBrightness()

    image_od = aug(image=image) ['image']
    mask_od = aug(image=mask) ['image']

    return image_od,mask_od

def rotate(image,mask):

    aug = Rotate()
    augmented = aug(image=image, mask=mask)
    image_od = augmented['image']
    mask_od = augmented['mask']
    return image_od,mask_od

def rGBShift(image,mask):

    aug = RGBShift()
    augmented = aug(image=image, mask=mask)
    image_od = augmented['image']
    mask_od = augmented['mask']
    return image_od,mask_od

def randomGamma(image,mask):

    aug = RandomGamma()
    augmented = aug(image=image, mask=mask)
    image_od = augmented['image']
    mask_od = augmented['mask']
    return image_od,mask_od

def flip(image,mask):
    aug = Flip()
    augmented = aug(image=image, mask=mask)

```

```

image_od = augmented['image']
mask_od = augmented['mask']
return image_od,mask_od

```

```

def hueSaturationValue(image,mask):

    aug = HueSaturationValue()
    augmented = aug(image=image, mask=mask)
    image_od = augmented['image']
    mask_od = augmented['mask']
    return image_od,mask_od

```

In [18]:

```
train_data = [i for i in X_train]
```

In [19]:

```
mask_data = [i for i in Y_train]
```

In [81]:

```
image = cv2.imread(train_data[3]);mask = cv2.imread(mask_data[3]) #converts the image into array
```

In [82]:

```

image_aug = horizontalFlip(image,mask) [0] #augmenting operation
mask_aug = horizontalFlip(image,mask) [1]

```

In [80]:

```
len(horizontalFlip(image,mask))
```

Out[80]:

2

In [85]:

```

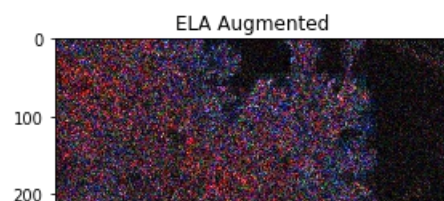
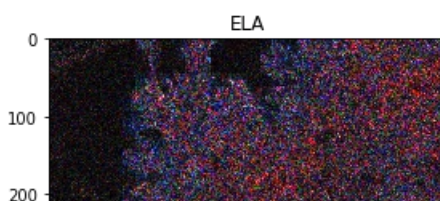
print('Horizontal Flip')
fig = plt.figure(figsize=(15,10))
ax1 = fig.add_subplot(221)
ax2 = fig.add_subplot(222)
ax3 = fig.add_subplot(223)
ax4 = fig.add_subplot(224)
ax1.set_title("ELA")
ax2.set_title("ELA Augmented")
ax3.set_title("Mask")
ax4.set_title("Mask Augmented")
ax1.imshow(image)
ax2.imshow(image_aug)
ax3.imshow(mask)
ax4.imshow(mask_aug)

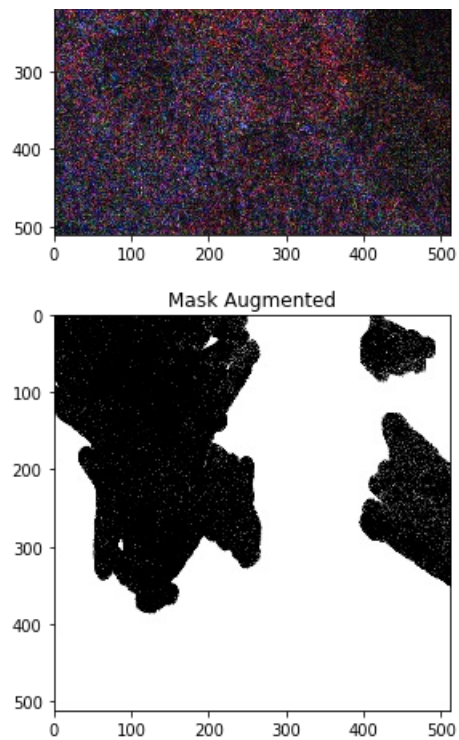
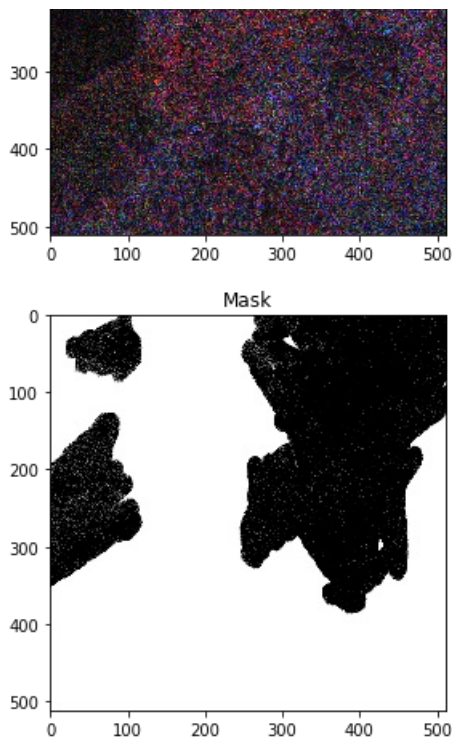
```

Horizontal Flip

Out[85]:

<matplotlib.image.AxesImage at 0x7f3fb7917f60>





In [93]:

```
image_aug = opticalDistortion(image,mask)[0] #augmenting operation
mask_aug = opticalDistortion(image,mask)[1]
```

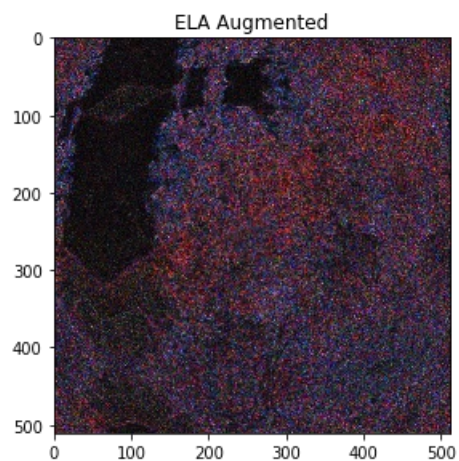
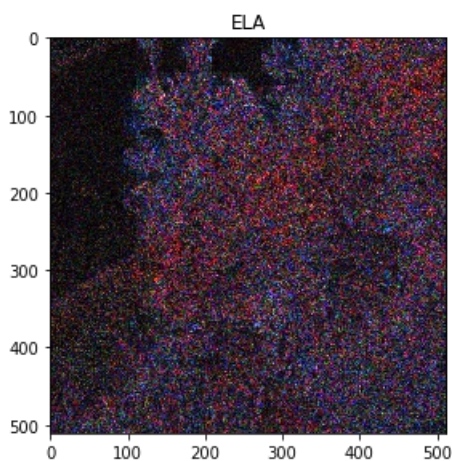
In [95]:

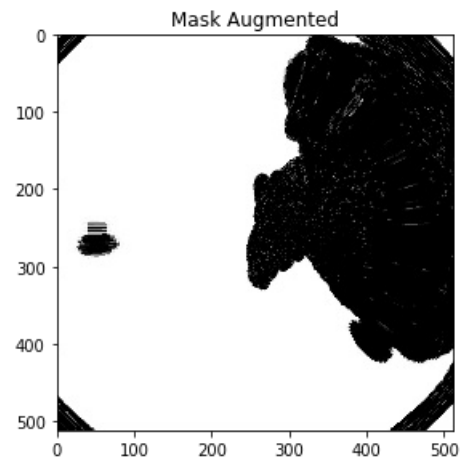
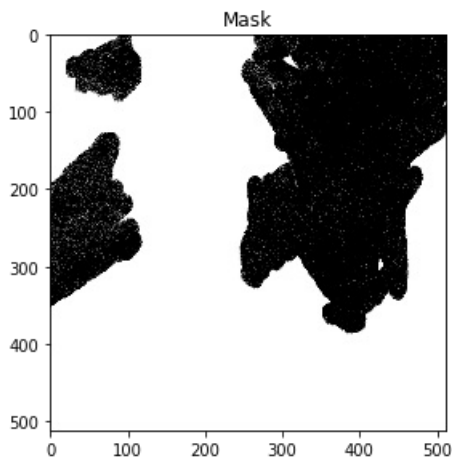
```
print('Optical Distortion')
fig = plt.figure(figsize=(15,10))
ax1 = fig.add_subplot(221)
ax2 = fig.add_subplot(222)
ax3 = fig.add_subplot(223)
ax4 = fig.add_subplot(224)
ax1.set_title("ELA")
ax2.set_title("ELA Augmented")
ax3.set_title("Mask")
ax4.set_title("Mask Augmented")
ax1.imshow(image)
ax2.imshow(image_aug)
ax3.imshow(mask)
ax4.imshow(mask_aug)
```

Optical Distortion

Out[95]:

<matplotlib.image.AxesImage at 0x7f3fb4237630>





In [101]:

```
image_aug = rGBShift(image,mask)[0] #augmenting operation
mask_aug = rGBShift(image,mask)[1]
```

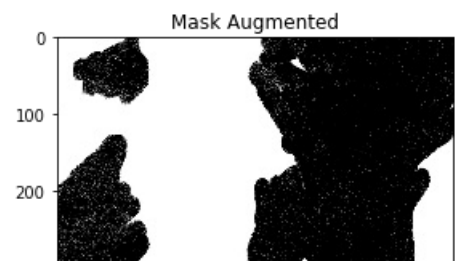
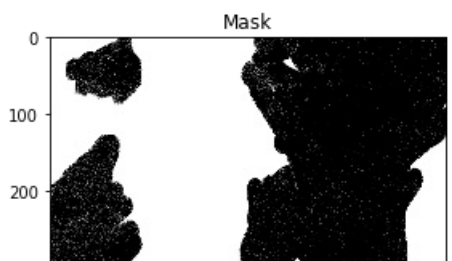
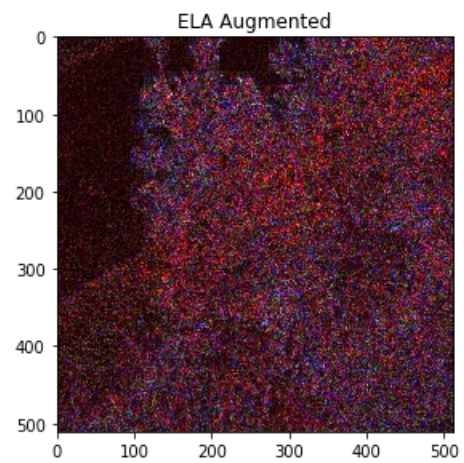
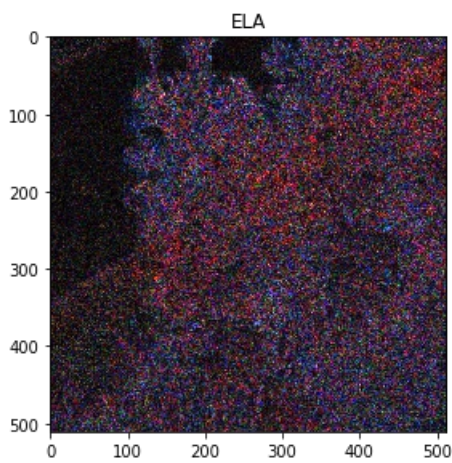
In [103]:

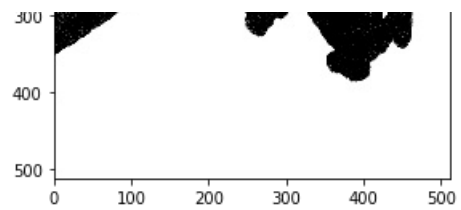
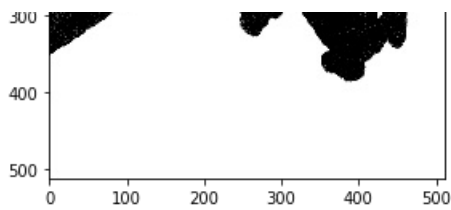
```
print('rgb shift')
fig = plt.figure(figsize=(15,10))
ax1 = fig.add_subplot(221)
ax2 = fig.add_subplot(222)
ax3 = fig.add_subplot(223)
ax4 = fig.add_subplot(224)
ax1.set_title("ELA")
ax2.set_title("ELA Augmented")
ax3.set_title("Mask")
ax4.set_title("Mask Augmented")
ax1.imshow(image)
ax2.imshow(image_aug)
ax3.imshow(mask)
ax4.imshow(mask_aug)
```

rgb shift

Out[103]:

<matplotlib.image.AxesImage at 0x7f3fb4045b70>





In [104]:

```
image_aug = gridDistortion(image,mask) [0]  #augmenting operation
mask_aug = gridDistortion(image,mask) [1]
```

In [111]:

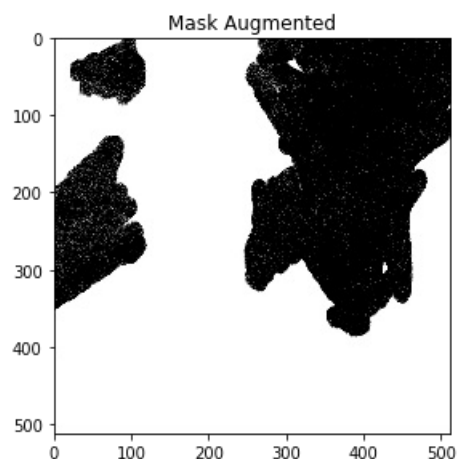
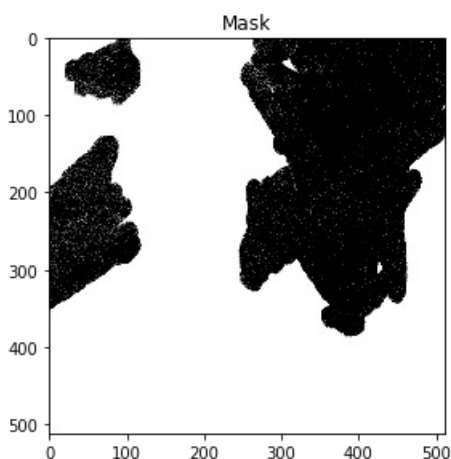
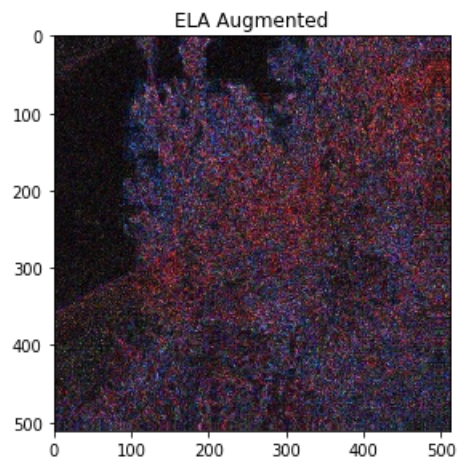
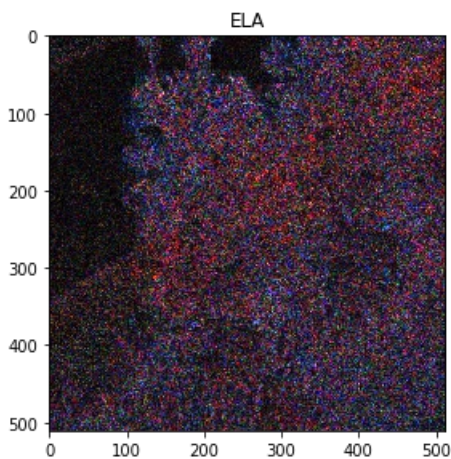
```
print('gridDistortion')
fig = plt.figure(figsize=(15,10))

ax1 = fig.add_subplot(221)
ax2 = fig.add_subplot(222)
ax3 = fig.add_subplot(223)
ax4 = fig.add_subplot(224)
ax1.set_title("ELA")
ax2.set_title("ELA Augmented")
ax3.set_title("Mask")
ax4.set_title("Mask Augmented")
ax1.imshow(image)
ax2.imshow(image_aug)
ax3.imshow(mask)
ax4.imshow(mask_aug)
```

gridDistortion

Out[111]:

<matplotlib.image.AxesImage at 0x7f3faf0ae9b0>



In [22]:

```
len(train_data), len(mask_data)
```

Out[22]:

(396, 396)

In [21]:

```
if not os.path.isfile(dataset_path+"phase2/"):
    os.makedirs(dataset_path+"phase2/ela_aug/")
    os.makedirs(dataset_path+"phase2/mask_aug/")
```

In [23]:

```
#####Performing various types of augmentations on Train data

for i in tqdm(range(len(train_data))):

    image=cv2.imread(train_data[i]);mask=cv2.imread(mask_data[i])
    ela_name = train_data[i][83:] ; mask_name = train_data[i][83:].replace('.png','mask.png')

    Image.fromarray(image).save(dataset_path+'phase2/ela_aug/'+ 'or_' + ela_name)
    Image.fromarray(image).save(dataset_path+'phase2/mask_aug/'+ 'or_' + mask_name)

    fl=flip(image,mask)
    Image.fromarray(fl[0]).save(dataset_path+'phase2/ela_aug/'+ 'fl_' + ela_name)
    Image.fromarray(fl[1]).save(dataset_path+'phase2/mask_aug/'+ 'fl_' + mask_name)

    hf=horizontalFlip(image,mask)
    Image.fromarray(hf[0]).save(dataset_path+'phase2/ela_aug/'+ 'hf_' + ela_name)
    Image.fromarray(hf[1]).save(dataset_path+'phase2/mask_aug/'+ 'hf_' + mask_name)

    vf=verticalFlip(image,mask)
    Image.fromarray(vf[0]).save(dataset_path+'phase2/ela_aug/'+ 'vf_' + ela_name)
    Image.fromarray(vf[1]).save(dataset_path+'phase2/mask_aug/'+ 'vf_' + mask_name)

    tp=transpose(image,mask)
    Image.fromarray(tp[0]).save(dataset_path+'phase2/ela_aug/'+ 'tp_' + ela_name)
    Image.fromarray(tp[1]).save(dataset_path+'phase2/mask_aug/'+ 'tp_' + mask_name)

    rr=randomRotate(image,mask)
    Image.fromarray(rr[0]).save(dataset_path+'phase2/ela_aug/'+ 'rr_' + ela_name)
    Image.fromarray(rr[1]).save(dataset_path+'phase2/mask_aug/'+ 'rr_' + mask_name)

    od=opticalDistortion(image,mask)
    Image.fromarray(od[0]).save(dataset_path+'phase2/ela_aug/'+ 'od_' + ela_name)
    Image.fromarray(od[1]).save(dataset_path+'phase2/mask_aug/'+ 'od_' + mask_name)

    ed=elasticDistortion(image,mask)
    Image.fromarray(ed[0]).save(dataset_path+'phase2/ela_aug/'+ 'ed_' + ela_name)
    Image.fromarray(ed[1]).save(dataset_path+'phase2/mask_aug/'+ 'ed_' + mask_name)

    sa=strong_Aug(image,mask)
    Image.fromarray(sa[0]).save(dataset_path+'phase2/ela_aug/'+ 'sa_' + ela_name)
    Image.fromarray(sa[1]).save(dataset_path+'phase2/mask_aug/'+ 'sa_' + mask_name)

    ch=channelShuffle(image,mask)
```

```

Image.fromarray(ch[0]).save(dataset_path+'phase2/ela_aug/'+ 'ch_' + ela_name)
Image.fromarray(ch[1]).save(dataset_path+'phase2/mask_aug/'+ 'ch_' + mask_name)

ac=aug_with_Crop(image,mask)
Image.fromarray(ac[0]).save(dataset_path+'phase2/ela_aug/'+ 'ac_' + ela_name)
Image.fromarray(ac[1]).save(dataset_path+'phase2/mask_aug/'+ 'ac_' + mask_name)

af=augment_flips_Color(image,mask)
Image.fromarray(af[0]).save(dataset_path+'phase2/ela_aug/'+ 'af_' + ela_name)
Image.fromarray(af[1]).save(dataset_path+'phase2/mask_aug/'+ 'af_' + mask_name)

gd=gridDistortion(image,mask)
Image.fromarray(gd[0]).save(dataset_path+'phase2/ela_aug/'+ 'gd_' + ela_name)
Image.fromarray(gd[1]).save(dataset_path+'phase2/mask_aug/'+ 'gd_' + mask_name)

ad=aug_Data_1(image,mask)
Image.fromarray(ad[0]).save(dataset_path+'phase2/ela_aug/'+ 'ad_' + ela_name)
Image.fromarray(ad[1]).save(dataset_path+'phase2/mask_aug/'+ 'ad_' + mask_name)

# ad2=aug_Data_2(image,mask)
# Image.fromarray(ad2[0]).save(dataset_path+'phase2/ela_aug/'+ 'd2_' + ela_name)
# Image.fromarray(ad2[1]).save(dataset_path+'phase2/mask_aug/'+ 'd2_' + mask_name)

# hs=hueSaturationValue(image,mask)
# Image.fromarray(hs[0]).save(dataset_path+'phase2/ela_aug/'+ 'hs_' + ela_name)
# Image.fromarray(hs[1]).save(dataset_path+'phase2/mask_aug/'+ 'hs_' + mask_name)

# rb=randomBrightness(image,mask)
# Image.fromarray(rb[0]).save(dataset_path+'phase2/ela_aug/'+ 'rb_' + ela_name)
# Image.fromarray(rb[1]).save(dataset_path+'phase2/mask_aug/'+ 'rb_' + mask_name)

# r=rotate(image,mask)
# Image.fromarray(r[0]).save(dataset_path+'phase2/ela_aug/'+ 'r_' + ela_name)
# Image.fromarray(r[1]).save(dataset_path+'phase2/mask_aug/'+ 'r_' + mask_name)

# rgb=rGBShift(image,mask)
# Image.fromarray(rgb[0]).save(dataset_path+'phase2/ela_aug/'+ 'rg_' + ela_name)
# Image.fromarray(rgb[1]).save(dataset_path+'phase2/mask_aug/'+ 'rg_' + mask_name)

# rgm=randomGamma(image,mask)
# Image.fromarray(rgm[0]).save(dataset_path+'phase2/ela_aug/'+ 'gm_' + ela_name)
# Image.fromarray(rgm[1]).save(dataset_path+'phase2/mask_aug/'+ 'gm_' + mask_name)

```

100%|██████████| 396/396 [15:03<00:00, 2.39s/it]

In [32]:

```

phase2_ela_aug = [dataset_path+'phase2/ela_aug/'+i for i in os.listdir(dataset_path+'phase2/ela_aug/')]

```

In [33]:

```

phase2_masks = [dataset_path+'phase2/mask_aug/'+i for i in os.listdir(dataset_path+'phase2/mask_aug/')]

```

In [34]:

```

phase2_ela_aug.sort()

```

In [35]:

```

phase2_masks.sort()

```

In [42]:

```
# final_X_train = phase2_ela_aug + X_train
```

In [43]:

```
# final_Y_train = phase2_masks + Y_train
```

In [44]:

```
# final_X_train.sort()
# final_Y_train.sort()
```

In [32]:

```
## save all the train and validation files into a text file using pickle
import pickle
with open("X_train.txt", "wb") as f:    #Pickling
    pickle.dump(X_train, f)

## save all the converted text into a text file using pickle
with open("Y_train.txt", "wb") as f:    #Pickling
    pickle.dump(Y_train, f)

with open("X_val.txt", "wb") as f:      #Pickling
    pickle.dump(X_val, f)

## save all the converted text into a text file using pickle
with open("Y_val.txt", "wb") as f:      #Pickling
    pickle.dump(Y_val, f)
```

In [51]:

```
# import pickle
# ## save all the train and validation files into a text file using pickle
# with open("final_X_train.txt", "wb") as f:    #Pickling
#     pickle.dump(final_X_train, f)

# ## save all the converted text into a text file using pickle
# with open("final_Y_train.txt", "wb") as f:    #Pickling
#     pickle.dump(final_Y_train, f)
```

In [42]:

```
## save all the train and validation files into a text file using pickle
import pickle
with open("X_val.txt", "wb") as f:    #Pickling
    pickle.dump(X_val, f)

## save all the converted text into a text file using pickle
with open("Y_val.txt", "wb") as f:    #Pickling
    pickle.dump(Y_val, f)

with open("X_train.txt", "wb") as f:    #Pickling
    pickle.dump(X_train, f)

## save all the converted text into a text file using pickle
with open("Y_train.txt", "wb") as f:    #Pickling
    pickle.dump(Y_train, f)
```

In [1]:

```
# #run this directly
import pickle
with open("X_val.txt", "rb") as f:    # Unpickling
    X_val = pickle.load(f)

with open("Y_val.txt", "rb") as f:    # Unpickling
    Y_val = pickle.load(f)
```

In [2]:

```
# with open("final_X_train.txt", "rb") as f:    # Unpickling
#     final_X_train = pickle.load(f)
# with open("final_Y_train.txt", "rb") as f:    # Unpickling
#     final_Y_train = pickle.load(f)
```

In [33]:

```
def metric(y_true, y_pred, smooth=1): # Dice_Coeff or F-Score
    y_true_f = K.flatten(y_true)
    y_pred_f = K.flatten(y_pred)
    intersection = K.sum(y_true_f * y_pred_f)
    return (2. * intersection + smooth) / (K.sum(y_true_f) + K.sum(y_pred_f) + smooth)
```

In [34]:

```
def LoadImages(batch):
    return np.array([resize(imread(file_name), (512, 512, 3)) for file_name in batch])
#https://stackoverflow.com/questions/47200146/keras-load-images-batch-wise-for-large-dataset
def loadImagesBatchwise(X_train,Y_train, batch_size):
    train_image_files=X_train
    train_mask_files=Y_train
    L = len(train_image_files)
    while True:
        batch_start = 0
        batch_end = batch_size

        while batch_start < L:
            limit = min(batch_end, L)
            X = LoadImages(train_image_files[batch_start:limit])
            Y = LoadImages(train_mask_files[batch_start:limit])
            yield (X,Y)
            batch_start += batch_size
            batch_end += batch_size
```

In [35]:

```
# https://github.com/qubvel/segmentation_models
from segmentation_models import Unet
model = Unet('resnet101', input_shape=(512, 512, 3), classes=3,
activation='sigmoid',encoder_weights='imagenet')

model.compile(optimizer=optimizers.Adam(), loss="binary_crossentropy", metrics=[metric])
```

Segmentation Models: using `keras` framework.

WARNING:tensorflow:From /home/ubuntu/anaconda3/lib/python3.6/site-packages/keras/backend/tensorflow_backend.py:541: The name tf.placeholder is deprecated. Please use tf.compat.v1.placeholder instead.

WARNING:tensorflow:From /home/ubuntu/anaconda3/lib/python3.6/site-packages/keras/backend/tensorflow_backend.py:66: The name tf.get_default_graph is deprecated. Please use tf.compat.v1.get_default_graph instead.

WARNING:tensorflow:From /home/ubuntu/anaconda3/lib/python3.6/site-packages/keras/backend/tensorflow_backend.py:190: The name tf.get_default_session is deprecated. Please use tf.compat.v1.get_default_session instead.

WARNING:tensorflow:From /home/ubuntu/anaconda3/lib/python3.6/site-packages/keras/backend/tensorflow_backend.py:197: The name tf.ConfigProto is deprecated. Please use tf.compat.v1.ConfigProto instead.

WARNING:tensorflow:From /home/ubuntu/anaconda3/lib/python3.6/site-packages/keras/backend/tensorflow_backend.py:203: The name tf.Session is deprecated. Please use tf.compat.v1.Session instead.

WARNING:tensorflow:From /home/ubuntu/anaconda3/lib/python3.6/site-packages/keras/backend/tensorflow_backend.py:2041: The name tf.nn.fused_batch_norm is deprecated. Please use tf.compat.v1.nn.fused_batch_norm instead.

WARNING:tensorflow:From /home/ubuntu/anaconda3/lib/python3.6/site-packages/keras/backend/tensorflow_backend.py:4267: The name tf.nn.max_pool is deprecated. Please use tf.nn.max_pool2d instead.

WARNING:tensorflow:From /home/ubuntu/anaconda3/lib/python3.6/site-packages/keras/backend/tensorflow_backend.py:2239: The name tf.image.resize_nearest_neighbor is deprecated. Please use tf.compat.v1.image.resize_nearest_neighbor instead.

WARNING:tensorflow:From /home/ubuntu/anaconda3/lib/python3.6/site-packages/keras/optimizers.py:793: The name tf.train.Optimizer is deprecated. Please use tf.compat.v1.train.Optimizer instead.

WARNING:tensorflow:From /home/ubuntu/anaconda3/lib/python3.6/site-packages/tensorflow/python/ops/nn_impl.py:180: add_dispatch_support.<locals>.wrapper (from tensorflow.python.ops.array_ops) is deprecated and will be removed in a future version. Instructions for updating:
Use tf.where in 2.0, which has the same broadcast rule as np.where

In [36]:

```
model.summary()
```

Model: "model_2"

Layer (type)	Output Shape	Param #	Connected to
data (InputLayer)	(None, 512, 512, 3)	0	
bn_data (BatchNormalization)	(None, 512, 512, 3)	9	data[0][0]
zero_padding2d_1 (ZeroPadding2D)	(None, 518, 518, 3)	0	bn_data[0][0]
conv0 (Conv2D)	(None, 256, 256, 64)	9408	zero_padding2d_1[0][0]
bn0 (BatchNormalization)	(None, 256, 256, 64)	256	conv0[0][0]
relu0 (Activation)	(None, 256, 256, 64)	0	bn0[0][0]
zero_padding2d_2 (ZeroPadding2D)	(None, 258, 258, 64)	0	relu0[0][0]
pooling0 (MaxPooling2D)	(None, 128, 128, 64)	0	zero_padding2d_2[0][0]
stage1_unit1_bn1 (BatchNormaliz	(None, 128, 128, 64)	256	pooling0[0][0]
stage1_unit1_relu1 (Activation)	(None, 128, 128, 64)	0	stage1_unit1_bn1[0][0]
stage1_unit1_conv1 (Conv2D)	(None, 128, 128, 64)	4096	stage1_unit1_relu1[0][0]
stage1_unit1_bn2 (BatchNormaliz	(None, 128, 128, 64)	256	stage1_unit1_conv1[0][0]
stage1_unit1_relu2 (Activation)	(None, 128, 128, 64)	0	stage1_unit1_bn2[0][0]
zero_padding2d_3 (ZeroPadding2D)	(None, 130, 130, 64)	0	stage1_unit1_relu2[0][0]
stage1_unit1_conv2 (Conv2D)	(None, 128, 128, 64)	36864	zero_padding2d_3[0][0]
stage1_unit1_bn3 (BatchNormaliz	(None, 128, 128, 64)	256	stage1_unit1_conv2[0][0]
stage1_unit1_relu3 (Activation)	(None, 128, 128, 64)	0	stage1_unit1_bn3[0][0]
stage1_unit1_conv3 (Conv2D)	(None, 128, 128, 256)	16384	stage1_unit1_relu3[0][0]
stage1_unit1_sc (Conv2D)	(None, 128, 128, 256)	16384	stage1_unit1_relu1[0][0]
add_1 (Add)	(None, 128, 128, 256)	0	stage1_unit1_conv3[0][0] stage1_unit1_sc[0][0]

stage1_unit2_bn1	(BatchNormaliz	(None, 128, 128, 256 1024	add_1[0][0]
stage1_unit2_relu1	(Activation)	(None, 128, 128, 256 0	stage1_unit2_bn1[0][0]
stage1_unit2_conv1	(Conv2D)	(None, 128, 128, 64) 16384	stage1_unit2_relu1[0][0]
stage1_unit2_bn2	(BatchNormaliz	(None, 128, 128, 64) 256	stage1_unit2_conv1[0][0]
stage1_unit2_relu2	(Activation)	(None, 128, 128, 64) 0	stage1_unit2_bn2[0][0]
zero_padding2d_4	(ZeroPadding2D	(None, 130, 130, 64) 0	stage1_unit2_relu2[0][0]
stage1_unit2_conv2	(Conv2D)	(None, 128, 128, 64) 36864	zero_padding2d_4[0][0]
stage1_unit2_bn3	(BatchNormaliz	(None, 128, 128, 64) 256	stage1_unit2_conv2[0][0]
stage1_unit2_relu3	(Activation)	(None, 128, 128, 64) 0	stage1_unit2_bn3[0][0]
stage1_unit2_conv3	(Conv2D)	(None, 128, 128, 256 16384	stage1_unit2_relu3[0][0]
add_2 (Add)		(None, 128, 128, 256 0	stage1_unit2_conv3[0][0] add_1[0][0]
stage1_unit3_bn1	(BatchNormaliz	(None, 128, 128, 256 1024	add_2[0][0]
stage1_unit3_relu1	(Activation)	(None, 128, 128, 256 0	stage1_unit3_bn1[0][0]
stage1_unit3_conv1	(Conv2D)	(None, 128, 128, 64) 16384	stage1_unit3_relu1[0][0]
stage1_unit3_bn2	(BatchNormaliz	(None, 128, 128, 64) 256	stage1_unit3_conv1[0][0]
stage1_unit3_relu2	(Activation)	(None, 128, 128, 64) 0	stage1_unit3_bn2[0][0]
zero_padding2d_5	(ZeroPadding2D	(None, 130, 130, 64) 0	stage1_unit3_relu2[0][0]
stage1_unit3_conv2	(Conv2D)	(None, 128, 128, 64) 36864	zero_padding2d_5[0][0]
stage1_unit3_bn3	(BatchNormaliz	(None, 128, 128, 64) 256	stage1_unit3_conv2[0][0]
stage1_unit3_relu3	(Activation)	(None, 128, 128, 64) 0	stage1_unit3_bn3[0][0]
stage1_unit3_conv3	(Conv2D)	(None, 128, 128, 256 16384	stage1_unit3_relu3[0][0]
add_3 (Add)		(None, 128, 128, 256 0	stage1_unit3_conv3[0][0] add_2[0][0]
stage2_unit1_bn1	(BatchNormaliz	(None, 128, 128, 256 1024	add_3[0][0]
stage2_unit1_relu1	(Activation)	(None, 128, 128, 256 0	stage2_unit1_bn1[0][0]
stage2_unit1_conv1	(Conv2D)	(None, 128, 128, 128 32768	stage2_unit1_relu1[0][0]
stage2_unit1_bn2	(BatchNormaliz	(None, 128, 128, 128 512	stage2_unit1_conv1[0][0]
stage2_unit1_relu2	(Activation)	(None, 128, 128, 128 0	stage2_unit1_bn2[0][0]
zero_padding2d_6	(ZeroPadding2D	(None, 130, 130, 128 0	stage2_unit1_relu2[0][0]
stage2_unit1_conv2	(Conv2D)	(None, 64, 64, 128) 147456	zero_padding2d_6[0][0]
stage2_unit1_bn3	(BatchNormaliz	(None, 64, 64, 128) 512	stage2_unit1_conv2[0][0]
stage2_unit1_relu3	(Activation)	(None, 64, 64, 128) 0	stage2_unit1_bn3[0][0]
stage2_unit1_conv3	(Conv2D)	(None, 64, 64, 512) 65536	stage2_unit1_relu3[0][0]
stage2_unit1_sc	(Conv2D)	(None, 64, 64, 512) 131072	stage2_unit1_relu1[0][0]
add_4 (Add)		(None, 64, 64, 512) 0	stage2_unit1_conv3[0][0] stage2_unit1_sc[0][0]
stage2_unit2_bn1	(BatchNormaliz	(None, 64, 64, 512) 2048	add_4[0][0]
stage2_unit2_relu1	(Activation)	(None, 64, 64, 512) 0	stage2_unit2_bn1[0][0]
stage2_unit2_conv1	(Conv2D)	(None, 64, 64, 128) 65536	stage2_unit2_relu1[0][0]

stage2_unit2_bn2	(BatchNormaliz	(None, 64, 64, 128)	512	stage2_unit2_conv1[0][0]
stage2_unit2_relu2	(Activation)	(None, 64, 64, 128)	0	stage2_unit2_bn2[0][0]
zero_padding2d_7	(ZeroPadding2D	(None, 66, 66, 128)	0	stage2_unit2_relu2[0][0]
stage2_unit2_conv2	(Conv2D)	(None, 64, 64, 128)	147456	zero_padding2d_7[0][0]
stage2_unit2_bn3	(BatchNormaliz	(None, 64, 64, 128)	512	stage2_unit2_conv2[0][0]
stage2_unit2_relu3	(Activation)	(None, 64, 64, 128)	0	stage2_unit2_bn3[0][0]
stage2_unit2_conv3	(Conv2D)	(None, 64, 64, 512)	65536	stage2_unit2_relu3[0][0]
add_5 (Add)		(None, 64, 64, 512)	0	stage2_unit2_conv3[0][0] add_4[0][0]
stage2_unit3_bn1	(BatchNormaliz	(None, 64, 64, 512)	2048	add_5[0][0]
stage2_unit3_relu1	(Activation)	(None, 64, 64, 512)	0	stage2_unit3_bn1[0][0]
stage2_unit3_conv1	(Conv2D)	(None, 64, 64, 128)	65536	stage2_unit3_relu1[0][0]
stage2_unit3_bn2	(BatchNormaliz	(None, 64, 64, 128)	512	stage2_unit3_conv1[0][0]
stage2_unit3_relu2	(Activation)	(None, 64, 64, 128)	0	stage2_unit3_bn2[0][0]
zero_padding2d_8	(ZeroPadding2D	(None, 66, 66, 128)	0	stage2_unit3_relu2[0][0]
stage2_unit3_conv2	(Conv2D)	(None, 64, 64, 128)	147456	zero_padding2d_8[0][0]
stage2_unit3_bn3	(BatchNormaliz	(None, 64, 64, 128)	512	stage2_unit3_conv2[0][0]
stage2_unit3_relu3	(Activation)	(None, 64, 64, 128)	0	stage2_unit3_bn3[0][0]
stage2_unit3_conv3	(Conv2D)	(None, 64, 64, 512)	65536	stage2_unit3_relu3[0][0]
add_6 (Add)		(None, 64, 64, 512)	0	stage2_unit3_conv3[0][0] add_5[0][0]
stage2_unit4_bn1	(BatchNormaliz	(None, 64, 64, 512)	2048	add_6[0][0]
stage2_unit4_relu1	(Activation)	(None, 64, 64, 512)	0	stage2_unit4_bn1[0][0]
stage2_unit4_conv1	(Conv2D)	(None, 64, 64, 128)	65536	stage2_unit4_relu1[0][0]
stage2_unit4_bn2	(BatchNormaliz	(None, 64, 64, 128)	512	stage2_unit4_conv1[0][0]
stage2_unit4_relu2	(Activation)	(None, 64, 64, 128)	0	stage2_unit4_bn2[0][0]
zero_padding2d_9	(ZeroPadding2D	(None, 66, 66, 128)	0	stage2_unit4_relu2[0][0]
stage2_unit4_conv2	(Conv2D)	(None, 64, 64, 128)	147456	zero_padding2d_9[0][0]
stage2_unit4_bn3	(BatchNormaliz	(None, 64, 64, 128)	512	stage2_unit4_conv2[0][0]
stage2_unit4_relu3	(Activation)	(None, 64, 64, 128)	0	stage2_unit4_bn3[0][0]
stage2_unit4_conv3	(Conv2D)	(None, 64, 64, 512)	65536	stage2_unit4_relu3[0][0]
add_7 (Add)		(None, 64, 64, 512)	0	stage2_unit4_conv3[0][0] add_6[0][0]
stage3_unit1_bn1	(BatchNormaliz	(None, 64, 64, 512)	2048	add_7[0][0]
stage3_unit1_relu1	(Activation)	(None, 64, 64, 512)	0	stage3_unit1_bn1[0][0]
stage3_unit1_conv1	(Conv2D)	(None, 64, 64, 256)	131072	stage3_unit1_relu1[0][0]
stage3_unit1_bn2	(BatchNormaliz	(None, 64, 64, 256)	1024	stage3_unit1_conv1[0][0]
stage3_unit1_relu2	(Activation)	(None, 64, 64, 256)	0	stage3_unit1_bn2[0][0]
zero_padding2d_10	(ZeroPadding2	(None, 66, 66, 256)	0	stage3_unit1_relu2[0][0]
stage3_unit1_conv2	(Conv2D)	(None, 32, 32, 256)	589824	zero_padding2d_10[0][0]

stage3_unit1_bn3	(BatchNormaliz	(None, 32, 32, 256)	1024	stage3_unit1_conv2[0][0]
stage3_unit1_relu3	(Activation)	(None, 32, 32, 256)	0	stage3_unit1_bn3[0][0]
stage3_unit1_conv3	(Conv2D)	(None, 32, 32, 1024)	262144	stage3_unit1_relu3[0][0]
stage3_unit1_sc	(Conv2D)	(None, 32, 32, 1024)	524288	stage3_unit1_relu1[0][0]
add_8	(Add)	(None, 32, 32, 1024)	0	stage3_unit1_conv3[0][0] stage3_unit1_sc[0][0]
stage3_unit2_bn1	(BatchNormaliz	(None, 32, 32, 1024)	4096	add_8[0][0]
stage3_unit2_relu1	(Activation)	(None, 32, 32, 1024)	0	stage3_unit2_bn1[0][0]
stage3_unit2_conv1	(Conv2D)	(None, 32, 32, 256)	262144	stage3_unit2_relu1[0][0]
stage3_unit2_bn2	(BatchNormaliz	(None, 32, 32, 256)	1024	stage3_unit2_conv1[0][0]
stage3_unit2_relu2	(Activation)	(None, 32, 32, 256)	0	stage3_unit2_bn2[0][0]
zero_padding2d_11	(ZeroPadding2	(None, 34, 34, 256)	0	stage3_unit2_relu2[0][0]
stage3_unit2_conv2	(Conv2D)	(None, 32, 32, 256)	589824	zero_padding2d_11[0][0]
stage3_unit2_bn3	(BatchNormaliz	(None, 32, 32, 256)	1024	stage3_unit2_conv2[0][0]
stage3_unit2_relu3	(Activation)	(None, 32, 32, 256)	0	stage3_unit2_bn3[0][0]
stage3_unit2_conv3	(Conv2D)	(None, 32, 32, 1024)	262144	stage3_unit2_relu3[0][0]
add_9	(Add)	(None, 32, 32, 1024)	0	stage3_unit2_conv3[0][0] add_8[0][0]
stage3_unit3_bn1	(BatchNormaliz	(None, 32, 32, 1024)	4096	add_9[0][0]
stage3_unit3_relu1	(Activation)	(None, 32, 32, 1024)	0	stage3_unit3_bn1[0][0]
stage3_unit3_conv1	(Conv2D)	(None, 32, 32, 256)	262144	stage3_unit3_relu1[0][0]
stage3_unit3_bn2	(BatchNormaliz	(None, 32, 32, 256)	1024	stage3_unit3_conv1[0][0]
stage3_unit3_relu2	(Activation)	(None, 32, 32, 256)	0	stage3_unit3_bn2[0][0]
zero_padding2d_12	(ZeroPadding2	(None, 34, 34, 256)	0	stage3_unit3_relu2[0][0]
stage3_unit3_conv2	(Conv2D)	(None, 32, 32, 256)	589824	zero_padding2d_12[0][0]
stage3_unit3_bn3	(BatchNormaliz	(None, 32, 32, 256)	1024	stage3_unit3_conv2[0][0]
stage3_unit3_relu3	(Activation)	(None, 32, 32, 256)	0	stage3_unit3_bn3[0][0]
stage3_unit3_conv3	(Conv2D)	(None, 32, 32, 1024)	262144	stage3_unit3_relu3[0][0]
add_10	(Add)	(None, 32, 32, 1024)	0	stage3_unit3_conv3[0][0] add_9[0][0]
stage3_unit4_bn1	(BatchNormaliz	(None, 32, 32, 1024)	4096	add_10[0][0]
stage3_unit4_relu1	(Activation)	(None, 32, 32, 1024)	0	stage3_unit4_bn1[0][0]
stage3_unit4_conv1	(Conv2D)	(None, 32, 32, 256)	262144	stage3_unit4_relu1[0][0]
stage3_unit4_bn2	(BatchNormaliz	(None, 32, 32, 256)	1024	stage3_unit4_conv1[0][0]
stage3_unit4_relu2	(Activation)	(None, 32, 32, 256)	0	stage3_unit4_bn2[0][0]
zero_padding2d_13	(ZeroPadding2	(None, 34, 34, 256)	0	stage3_unit4_relu2[0][0]
stage3_unit4_conv2	(Conv2D)	(None, 32, 32, 256)	589824	zero_padding2d_13[0][0]
stage3_unit4_bn3	(BatchNormaliz	(None, 32, 32, 256)	1024	stage3_unit4_conv2[0][0]
stage3_unit4_relu3	(Activation)	(None, 32, 32, 256)	0	stage3_unit4_bn3[0][0]
stage3_unit4_conv3	(Conv2D)	(None, 32, 32, 1024)	262144	stage3_unit4_relu3[0][0]

add_11 (Add)	(None, 32, 32, 1024)	0	stage3_unit4_conv3[0][0] add_10[0][0]
stage3_unit5_bn1 (BatchNormaliz	(None, 32, 32, 1024)	4096	add_11[0][0]
stage3_unit5_relu1 (Activation)	(None, 32, 32, 1024)	0	stage3_unit5_bn1[0][0]
stage3_unit5_conv1 (Conv2D)	(None, 32, 32, 256)	262144	stage3_unit5_relu1[0][0]
stage3_unit5_bn2 (BatchNormaliz	(None, 32, 32, 256)	1024	stage3_unit5_conv1[0][0]
stage3_unit5_relu2 (Activation)	(None, 32, 32, 256)	0	stage3_unit5_bn2[0][0]
zero_padding2d_14 (ZeroPadding2	(None, 34, 34, 256)	0	stage3_unit5_relu2[0][0]
stage3_unit5_conv2 (Conv2D)	(None, 32, 32, 256)	589824	zero_padding2d_14[0][0]
stage3_unit5_bn3 (BatchNormaliz	(None, 32, 32, 256)	1024	stage3_unit5_conv2[0][0]
stage3_unit5_relu3 (Activation)	(None, 32, 32, 256)	0	stage3_unit5_bn3[0][0]
stage3_unit5_conv3 (Conv2D)	(None, 32, 32, 1024)	262144	stage3_unit5_relu3[0][0]
add_12 (Add)	(None, 32, 32, 1024)	0	stage3_unit5_conv3[0][0] add_11[0][0]
stage3_unit6_bn1 (BatchNormaliz	(None, 32, 32, 1024)	4096	add_12[0][0]
stage3_unit6_relu1 (Activation)	(None, 32, 32, 1024)	0	stage3_unit6_bn1[0][0]
stage3_unit6_conv1 (Conv2D)	(None, 32, 32, 256)	262144	stage3_unit6_relu1[0][0]
stage3_unit6_bn2 (BatchNormaliz	(None, 32, 32, 256)	1024	stage3_unit6_conv1[0][0]
stage3_unit6_relu2 (Activation)	(None, 32, 32, 256)	0	stage3_unit6_bn2[0][0]
zero_padding2d_15 (ZeroPadding2	(None, 34, 34, 256)	0	stage3_unit6_relu2[0][0]
stage3_unit6_conv2 (Conv2D)	(None, 32, 32, 256)	589824	zero_padding2d_15[0][0]
stage3_unit6_bn3 (BatchNormaliz	(None, 32, 32, 256)	1024	stage3_unit6_conv2[0][0]
stage3_unit6_relu3 (Activation)	(None, 32, 32, 256)	0	stage3_unit6_bn3[0][0]
stage3_unit6_conv3 (Conv2D)	(None, 32, 32, 1024)	262144	stage3_unit6_relu3[0][0]
add_13 (Add)	(None, 32, 32, 1024)	0	stage3_unit6_conv3[0][0] add_12[0][0]
stage3_unit7_bn1 (BatchNormaliz	(None, 32, 32, 1024)	4096	add_13[0][0]
stage3_unit7_relu1 (Activation)	(None, 32, 32, 1024)	0	stage3_unit7_bn1[0][0]
stage3_unit7_conv1 (Conv2D)	(None, 32, 32, 256)	262144	stage3_unit7_relu1[0][0]
stage3_unit7_bn2 (BatchNormaliz	(None, 32, 32, 256)	1024	stage3_unit7_conv1[0][0]
stage3_unit7_relu2 (Activation)	(None, 32, 32, 256)	0	stage3_unit7_bn2[0][0]
zero_padding2d_16 (ZeroPadding2	(None, 34, 34, 256)	0	stage3_unit7_relu2[0][0]
stage3_unit7_conv2 (Conv2D)	(None, 32, 32, 256)	589824	zero_padding2d_16[0][0]
stage3_unit7_bn3 (BatchNormaliz	(None, 32, 32, 256)	1024	stage3_unit7_conv2[0][0]
stage3_unit7_relu3 (Activation)	(None, 32, 32, 256)	0	stage3_unit7_bn3[0][0]
stage3_unit7_conv3 (Conv2D)	(None, 32, 32, 1024)	262144	stage3_unit7_relu3[0][0]
add_14 (Add)	(None, 32, 32, 1024)	0	stage3_unit7_conv3[0][0] add_13[0][0]
stage3_unit8_bn1 (BatchNormaliz	(None, 32, 32, 1024)	4096	add_14[0][0]
stage3_unit8_relu1 (Activation)	(None, 32, 32, 1024)	0	stage3_unit8_bn1[0][0]
stage3_unit8_conv1 (Conv2D)	(None, 32, 32, 256)	262144	stage3_unit8_relu1[0][0]

stage3_unit8_conv1 (Conv2D)	(None, 32, 32, 256)	1024	stage3_unit8_conv1[0][0]
stage3_unit8_bn2 (BatchNormaliz	(None, 32, 32, 256)	1024	stage3_unit8_bn2[0][0]
stage3_unit8_relu2 (Activation)	(None, 32, 32, 256)	0	stage3_unit8_relu2[0][0]
zero_padding2d_17 (ZeroPadding2	(None, 34, 34, 256)	0	stage3_unit8_relu2[0][0]
stage3_unit8_conv2 (Conv2D)	(None, 32, 32, 256)	589824	zero_padding2d_17[0][0]
stage3_unit8_bn3 (BatchNormaliz	(None, 32, 32, 256)	1024	stage3_unit8_conv2[0][0]
stage3_unit8_relu3 (Activation)	(None, 32, 32, 256)	0	stage3_unit8_bn3[0][0]
stage3_unit8_conv3 (Conv2D)	(None, 32, 32, 1024)	262144	stage3_unit8_relu3[0][0]
add_15 (Add)	(None, 32, 32, 1024)	0	stage3_unit8_conv3[0][0] add_14[0][0]
stage3_unit9_bn1 (BatchNormaliz	(None, 32, 32, 1024)	4096	add_15[0][0]
stage3_unit9_relu1 (Activation)	(None, 32, 32, 1024)	0	stage3_unit9_bn1[0][0]
stage3_unit9_conv1 (Conv2D)	(None, 32, 32, 256)	262144	stage3_unit9_relu1[0][0]
stage3_unit9_bn2 (BatchNormaliz	(None, 32, 32, 256)	1024	stage3_unit9_conv1[0][0]
stage3_unit9_relu2 (Activation)	(None, 32, 32, 256)	0	stage3_unit9_bn2[0][0]
zero_padding2d_18 (ZeroPadding2	(None, 34, 34, 256)	0	stage3_unit9_relu2[0][0]
stage3_unit9_conv2 (Conv2D)	(None, 32, 32, 256)	589824	zero_padding2d_18[0][0]
stage3_unit9_bn3 (BatchNormaliz	(None, 32, 32, 256)	1024	stage3_unit9_conv2[0][0]
stage3_unit9_relu3 (Activation)	(None, 32, 32, 256)	0	stage3_unit9_bn3[0][0]
stage3_unit9_conv3 (Conv2D)	(None, 32, 32, 1024)	262144	stage3_unit9_relu3[0][0]
add_16 (Add)	(None, 32, 32, 1024)	0	stage3_unit9_conv3[0][0] add_15[0][0]
stage3_unit10_bn1 (BatchNormali	(None, 32, 32, 1024)	4096	add_16[0][0]
stage3_unit10_relu1 (Activation	(None, 32, 32, 1024)	0	stage3_unit10_bn1[0][0]
stage3_unit10_conv1 (Conv2D)	(None, 32, 32, 256)	262144	stage3_unit10_relu1[0][0]
stage3_unit10_bn2 (BatchNormali	(None, 32, 32, 256)	1024	stage3_unit10_conv1[0][0]
stage3_unit10_relu2 (Activation	(None, 32, 32, 256)	0	stage3_unit10_bn2[0][0]
zero_padding2d_19 (ZeroPadding2	(None, 34, 34, 256)	0	stage3_unit10_relu2[0][0]
stage3_unit10_conv2 (Conv2D)	(None, 32, 32, 256)	589824	zero_padding2d_19[0][0]
stage3_unit10_bn3 (BatchNormali	(None, 32, 32, 256)	1024	stage3_unit10_conv2[0][0]
stage3_unit10_relu3 (Activation	(None, 32, 32, 256)	0	stage3_unit10_bn3[0][0]
stage3_unit10_conv3 (Conv2D)	(None, 32, 32, 1024)	262144	stage3_unit10_relu3[0][0]
add_17 (Add)	(None, 32, 32, 1024)	0	stage3_unit10_conv3[0][0] add_16[0][0]
stage3_unit11_bn1 (BatchNormali	(None, 32, 32, 1024)	4096	add_17[0][0]
stage3_unit11_relu1 (Activation	(None, 32, 32, 1024)	0	stage3_unit11_bn1[0][0]
stage3_unit11_conv1 (Conv2D)	(None, 32, 32, 256)	262144	stage3_unit11_relu1[0][0]
stage3_unit11_bn2 (BatchNormali	(None, 32, 32, 256)	1024	stage3_unit11_conv1[0][0]
stage3_unit11_relu2 (Activation	(None, 32, 32, 256)	0	stage3_unit11_bn2[0][0]
zero_padding2d_20 (ZeroPadding2	(None, 34, 34, 256)	0	stage3_unit11_relu2[0][0]
stage3_unit11_conv2 (Conv2D)	(None, 32, 32, 256)	589824	zero_padding2d_20[0][0]

stage3_unit11_conv2	(Conv2D)	(None, 32, 32, 256)	1024	stage3_unit11_conv2[0][0]
stage3_unit11_bn3	(BatchNormali	(None, 32, 32, 256)	1024	stage3_unit11_bn3[0][0]
stage3_unit11_relu3	(Activation	(None, 32, 32, 256)	0	stage3_unit11_relu3[0][0]
stage3_unit11_conv3	(Conv2D)	(None, 32, 32, 1024)	262144	stage3_unit11_conv3[0][0]
add_18	(Add)	(None, 32, 32, 1024)	0	add_17[0][0]
stage3_unit12_bn1	(BatchNormali	(None, 32, 32, 1024)	4096	add_18[0][0]
stage3_unit12_relu1	(Activation	(None, 32, 32, 1024)	0	stage3_unit12_bn1[0][0]
stage3_unit12_conv1	(Conv2D)	(None, 32, 32, 256)	262144	stage3_unit12_relu1[0][0]
stage3_unit12_bn2	(BatchNormali	(None, 32, 32, 256)	1024	stage3_unit12_conv1[0][0]
stage3_unit12_relu2	(Activation	(None, 32, 32, 256)	0	stage3_unit12_bn2[0][0]
zero_padding2d_21	(ZeroPadding2	(None, 34, 34, 256)	0	stage3_unit12_relu2[0][0]
stage3_unit12_conv2	(Conv2D)	(None, 32, 32, 256)	589824	zero_padding2d_21[0][0]
stage3_unit12_bn3	(BatchNormali	(None, 32, 32, 256)	1024	stage3_unit12_conv2[0][0]
stage3_unit12_relu3	(Activation	(None, 32, 32, 256)	0	stage3_unit12_bn3[0][0]
stage3_unit12_conv3	(Conv2D)	(None, 32, 32, 1024)	262144	stage3_unit12_relu3[0][0]
add_19	(Add)	(None, 32, 32, 1024)	0	add_18[0][0]
stage3_unit13_bn1	(BatchNormali	(None, 32, 32, 1024)	4096	add_19[0][0]
stage3_unit13_relu1	(Activation	(None, 32, 32, 1024)	0	stage3_unit13_bn1[0][0]
stage3_unit13_conv1	(Conv2D)	(None, 32, 32, 256)	262144	stage3_unit13_relu1[0][0]
stage3_unit13_bn2	(BatchNormali	(None, 32, 32, 256)	1024	stage3_unit13_conv1[0][0]
stage3_unit13_relu2	(Activation	(None, 32, 32, 256)	0	stage3_unit13_bn2[0][0]
zero_padding2d_22	(ZeroPadding2	(None, 34, 34, 256)	0	stage3_unit13_relu2[0][0]
stage3_unit13_conv2	(Conv2D)	(None, 32, 32, 256)	589824	zero_padding2d_22[0][0]
stage3_unit13_bn3	(BatchNormali	(None, 32, 32, 256)	1024	stage3_unit13_conv2[0][0]
stage3_unit13_relu3	(Activation	(None, 32, 32, 256)	0	stage3_unit13_bn3[0][0]
stage3_unit13_conv3	(Conv2D)	(None, 32, 32, 1024)	262144	stage3_unit13_relu3[0][0]
add_20	(Add)	(None, 32, 32, 1024)	0	add_19[0][0]
stage3_unit14_bn1	(BatchNormali	(None, 32, 32, 1024)	4096	add_20[0][0]
stage3_unit14_relu1	(Activation	(None, 32, 32, 1024)	0	stage3_unit14_bn1[0][0]
stage3_unit14_conv1	(Conv2D)	(None, 32, 32, 256)	262144	stage3_unit14_relu1[0][0]
stage3_unit14_bn2	(BatchNormali	(None, 32, 32, 256)	1024	stage3_unit14_conv1[0][0]
stage3_unit14_relu2	(Activation	(None, 32, 32, 256)	0	stage3_unit14_bn2[0][0]
zero_padding2d_23	(ZeroPadding2	(None, 34, 34, 256)	0	stage3_unit14_relu2[0][0]
stage3_unit14_conv2	(Conv2D)	(None, 32, 32, 256)	589824	zero_padding2d_23[0][0]
stage3_unit14_bn3	(BatchNormali	(None, 32, 32, 256)	1024	stage3_unit14_conv2[0][0]
stage3_unit14_relu3	(Activation	(None, 32, 32, 256)	0	stage3_unit14_bn3[0][0]
stage3_unit14_conv3	(Conv2D)	(None, 32, 32, 1024)	262144	stage3_unit14_relu3[0][0]
add_21	(Add)	(None, 32, 32, 1024)	0	stage3_unit14_conv3[0][0]

add_21 (Add)	(None, 32, 32, 1024) 0	stage3_unit15_conv3[0][0] add_20[0][0]
stage3_unit15_bn1 (BatchNormali	(None, 32, 32, 1024) 4096	add_21[0][0]
stage3_unit15_relu1 (Activation	(None, 32, 32, 1024) 0	stage3_unit15_bn1[0][0]
stage3_unit15_conv1 (Conv2D)	(None, 32, 32, 256) 262144	stage3_unit15_relu1[0][0]
stage3_unit15_bn2 (BatchNormali	(None, 32, 32, 256) 1024	stage3_unit15_conv1[0][0]
stage3_unit15_relu2 (Activation	(None, 32, 32, 256) 0	stage3_unit15_bn2[0][0]
zero_padding2d_24 (ZeroPadding2	(None, 34, 34, 256) 0	stage3_unit15_relu2[0][0]
stage3_unit15_conv2 (Conv2D)	(None, 32, 32, 256) 589824	zero_padding2d_24[0][0]
stage3_unit15_bn3 (BatchNormali	(None, 32, 32, 256) 1024	stage3_unit15_conv2[0][0]
stage3_unit15_relu3 (Activation	(None, 32, 32, 256) 0	stage3_unit15_bn3[0][0]
stage3_unit15_conv3 (Conv2D)	(None, 32, 32, 1024) 262144	stage3_unit15_relu3[0][0]
add_22 (Add)	(None, 32, 32, 1024) 0	stage3_unit15_conv3[0][0] add_21[0][0]
stage3_unit16_bn1 (BatchNormali	(None, 32, 32, 1024) 4096	add_22[0][0]
stage3_unit16_relu1 (Activation	(None, 32, 32, 1024) 0	stage3_unit16_bn1[0][0]
stage3_unit16_conv1 (Conv2D)	(None, 32, 32, 256) 262144	stage3_unit16_relu1[0][0]
stage3_unit16_bn2 (BatchNormali	(None, 32, 32, 256) 1024	stage3_unit16_conv1[0][0]
stage3_unit16_relu2 (Activation	(None, 32, 32, 256) 0	stage3_unit16_bn2[0][0]
zero_padding2d_25 (ZeroPadding2	(None, 34, 34, 256) 0	stage3_unit16_relu2[0][0]
stage3_unit16_conv2 (Conv2D)	(None, 32, 32, 256) 589824	zero_padding2d_25[0][0]
stage3_unit16_bn3 (BatchNormali	(None, 32, 32, 256) 1024	stage3_unit16_conv2[0][0]
stage3_unit16_relu3 (Activation	(None, 32, 32, 256) 0	stage3_unit16_bn3[0][0]
stage3_unit16_conv3 (Conv2D)	(None, 32, 32, 1024) 262144	stage3_unit16_relu3[0][0]
add_23 (Add)	(None, 32, 32, 1024) 0	stage3_unit16_conv3[0][0] add_22[0][0]
stage3_unit17_bn1 (BatchNormali	(None, 32, 32, 1024) 4096	add_23[0][0]
stage3_unit17_relu1 (Activation	(None, 32, 32, 1024) 0	stage3_unit17_bn1[0][0]
stage3_unit17_conv1 (Conv2D)	(None, 32, 32, 256) 262144	stage3_unit17_relu1[0][0]
stage3_unit17_bn2 (BatchNormali	(None, 32, 32, 256) 1024	stage3_unit17_conv1[0][0]
stage3_unit17_relu2 (Activation	(None, 32, 32, 256) 0	stage3_unit17_bn2[0][0]
zero_padding2d_26 (ZeroPadding2	(None, 34, 34, 256) 0	stage3_unit17_relu2[0][0]
stage3_unit17_conv2 (Conv2D)	(None, 32, 32, 256) 589824	zero_padding2d_26[0][0]
stage3_unit17_bn3 (BatchNormali	(None, 32, 32, 256) 1024	stage3_unit17_conv2[0][0]
stage3_unit17_relu3 (Activation	(None, 32, 32, 256) 0	stage3_unit17_bn3[0][0]
stage3_unit17_conv3 (Conv2D)	(None, 32, 32, 1024) 262144	stage3_unit17_relu3[0][0]
add_24 (Add)	(None, 32, 32, 1024) 0	stage3_unit17_conv3[0][0] add_23[0][0]
stage3_unit18_bn1 (BatchNormali	(None, 32, 32, 1024) 4096	add_24[0][0]
stage3_unit18_relu1 (Activation	(None, 32, 32, 1024) 0	stage3_unit18_bn1[0][0]
stage3_unit18_conv1 (Conv2D)	(None, 32, 32, 256) 262144	stage3_unit18_relu1[0][0]

stage3_unit18_bn2	(BatchNormali	(None, 32, 32, 256)	1024	stage3_unit18_conv1[0][0]
stage3_unit18_relu2	(Activation	(None, 32, 32, 256)	0	stage3_unit18_bn2[0][0]
zero_padding2d_27	(ZeroPadding2	(None, 34, 34, 256)	0	stage3_unit18_relu2[0][0]
stage3_unit18_conv2	(Conv2D)	(None, 32, 32, 256)	589824	zero_padding2d_27[0][0]
stage3_unit18_bn3	(BatchNormali	(None, 32, 32, 256)	1024	stage3_unit18_conv2[0][0]
stage3_unit18_relu3	(Activation	(None, 32, 32, 256)	0	stage3_unit18_bn3[0][0]
stage3_unit18_conv3	(Conv2D)	(None, 32, 32, 1024)	262144	stage3_unit18_relu3[0][0]
add_25 (Add)		(None, 32, 32, 1024)	0	stage3_unit18_conv3[0][0] add_24[0][0]
stage3_unit19_bn1	(BatchNormali	(None, 32, 32, 1024)	4096	add_25[0][0]
stage3_unit19_relu1	(Activation	(None, 32, 32, 1024)	0	stage3_unit19_bn1[0][0]
stage3_unit19_conv1	(Conv2D)	(None, 32, 32, 256)	262144	stage3_unit19_relu1[0][0]
stage3_unit19_bn2	(BatchNormali	(None, 32, 32, 256)	1024	stage3_unit19_conv1[0][0]
stage3_unit19_relu2	(Activation	(None, 32, 32, 256)	0	stage3_unit19_bn2[0][0]
zero_padding2d_28	(ZeroPadding2	(None, 34, 34, 256)	0	stage3_unit19_relu2[0][0]
stage3_unit19_conv2	(Conv2D)	(None, 32, 32, 256)	589824	zero_padding2d_28[0][0]
stage3_unit19_bn3	(BatchNormali	(None, 32, 32, 256)	1024	stage3_unit19_conv2[0][0]
stage3_unit19_relu3	(Activation	(None, 32, 32, 256)	0	stage3_unit19_bn3[0][0]
stage3_unit19_conv3	(Conv2D)	(None, 32, 32, 1024)	262144	stage3_unit19_relu3[0][0]
add_26 (Add)		(None, 32, 32, 1024)	0	stage3_unit19_conv3[0][0] add_25[0][0]
stage3_unit20_bn1	(BatchNormali	(None, 32, 32, 1024)	4096	add_26[0][0]
stage3_unit20_relu1	(Activation	(None, 32, 32, 1024)	0	stage3_unit20_bn1[0][0]
stage3_unit20_conv1	(Conv2D)	(None, 32, 32, 256)	262144	stage3_unit20_relu1[0][0]
stage3_unit20_bn2	(BatchNormali	(None, 32, 32, 256)	1024	stage3_unit20_conv1[0][0]
stage3_unit20_relu2	(Activation	(None, 32, 32, 256)	0	stage3_unit20_bn2[0][0]
zero_padding2d_29	(ZeroPadding2	(None, 34, 34, 256)	0	stage3_unit20_relu2[0][0]
stage3_unit20_conv2	(Conv2D)	(None, 32, 32, 256)	589824	zero_padding2d_29[0][0]
stage3_unit20_bn3	(BatchNormali	(None, 32, 32, 256)	1024	stage3_unit20_conv2[0][0]
stage3_unit20_relu3	(Activation	(None, 32, 32, 256)	0	stage3_unit20_bn3[0][0]
stage3_unit20_conv3	(Conv2D)	(None, 32, 32, 1024)	262144	stage3_unit20_relu3[0][0]
add_27 (Add)		(None, 32, 32, 1024)	0	stage3_unit20_conv3[0][0] add_26[0][0]
stage3_unit21_bn1	(BatchNormali	(None, 32, 32, 1024)	4096	add_27[0][0]
stage3_unit21_relu1	(Activation	(None, 32, 32, 1024)	0	stage3_unit21_bn1[0][0]
stage3_unit21_conv1	(Conv2D)	(None, 32, 32, 256)	262144	stage3_unit21_relu1[0][0]
stage3_unit21_bn2	(BatchNormali	(None, 32, 32, 256)	1024	stage3_unit21_conv1[0][0]
stage3_unit21_relu2	(Activation	(None, 32, 32, 256)	0	stage3_unit21_bn2[0][0]
zero_padding2d_30	(ZeroPadding2	(None, 34, 34, 256)	0	stage3_unit21_relu2[0][0]
stage3_unit21_conv2	(Conv2D)	(None, 32, 32, 256)	589824	zero_padding2d_30[0][0]

stage3_unit21_bn3	(BatchNormali	(None, 32, 32, 256)	1024	stage3_unit21_conv2[0][0]
stage3_unit21_relu3	(Activation	(None, 32, 32, 256)	0	stage3_unit21_bn3[0][0]
stage3_unit21_conv3	(Conv2D)	(None, 32, 32, 1024)	262144	stage3_unit21_relu3[0][0]
add_28	(Add)	(None, 32, 32, 1024)	0	stage3_unit21_conv3[0][0] add_27[0][0]
stage3_unit22_bn1	(BatchNormali	(None, 32, 32, 1024)	4096	add_28[0][0]
stage3_unit22_relu1	(Activation	(None, 32, 32, 1024)	0	stage3_unit22_bn1[0][0]
stage3_unit22_conv1	(Conv2D)	(None, 32, 32, 256)	262144	stage3_unit22_relu1[0][0]
stage3_unit22_bn2	(BatchNormali	(None, 32, 32, 256)	1024	stage3_unit22_conv1[0][0]
stage3_unit22_relu2	(Activation	(None, 32, 32, 256)	0	stage3_unit22_bn2[0][0]
zero_padding2d_31	(ZeroPadding2	(None, 34, 34, 256)	0	stage3_unit22_relu2[0][0]
stage3_unit22_conv2	(Conv2D)	(None, 32, 32, 256)	589824	zero_padding2d_31[0][0]
stage3_unit22_bn3	(BatchNormali	(None, 32, 32, 256)	1024	stage3_unit22_conv2[0][0]
stage3_unit22_relu3	(Activation	(None, 32, 32, 256)	0	stage3_unit22_bn3[0][0]
stage3_unit22_conv3	(Conv2D)	(None, 32, 32, 1024)	262144	stage3_unit22_relu3[0][0]
add_29	(Add)	(None, 32, 32, 1024)	0	stage3_unit22_conv3[0][0] add_28[0][0]
stage3_unit23_bn1	(BatchNormali	(None, 32, 32, 1024)	4096	add_29[0][0]
stage3_unit23_relu1	(Activation	(None, 32, 32, 1024)	0	stage3_unit23_bn1[0][0]
stage3_unit23_conv1	(Conv2D)	(None, 32, 32, 256)	262144	stage3_unit23_relu1[0][0]
stage3_unit23_bn2	(BatchNormali	(None, 32, 32, 256)	1024	stage3_unit23_conv1[0][0]
stage3_unit23_relu2	(Activation	(None, 32, 32, 256)	0	stage3_unit23_bn2[0][0]
zero_padding2d_32	(ZeroPadding2	(None, 34, 34, 256)	0	stage3_unit23_relu2[0][0]
stage3_unit23_conv2	(Conv2D)	(None, 32, 32, 256)	589824	zero_padding2d_32[0][0]
stage3_unit23_bn3	(BatchNormali	(None, 32, 32, 256)	1024	stage3_unit23_conv2[0][0]
stage3_unit23_relu3	(Activation	(None, 32, 32, 256)	0	stage3_unit23_bn3[0][0]
stage3_unit23_conv3	(Conv2D)	(None, 32, 32, 1024)	262144	stage3_unit23_relu3[0][0]
add_30	(Add)	(None, 32, 32, 1024)	0	stage3_unit23_conv3[0][0] add_29[0][0]
stage4_unit1_bn1	(BatchNormaliz	(None, 32, 32, 1024)	4096	add_30[0][0]
stage4_unit1_relu1	(Activation)	(None, 32, 32, 1024)	0	stage4_unit1_bn1[0][0]
stage4_unit1_conv1	(Conv2D)	(None, 32, 32, 512)	524288	stage4_unit1_relu1[0][0]
stage4_unit1_bn2	(BatchNormaliz	(None, 32, 32, 512)	2048	stage4_unit1_conv1[0][0]
stage4_unit1_relu2	(Activation)	(None, 32, 32, 512)	0	stage4_unit1_bn2[0][0]
zero_padding2d_33	(ZeroPadding2	(None, 34, 34, 512)	0	stage4_unit1_relu2[0][0]
stage4_unit1_conv2	(Conv2D)	(None, 16, 16, 512)	2359296	zero_padding2d_33[0][0]
stage4_unit1_bn3	(BatchNormaliz	(None, 16, 16, 512)	2048	stage4_unit1_conv2[0][0]
stage4_unit1_relu3	(Activation)	(None, 16, 16, 512)	0	stage4_unit1_bn3[0][0]
stage4_unit1_conv3	(Conv2D)	(None, 16, 16, 2048)	1048576	stage4_unit1_relu3[0][0]
stage4_unit1_sc	(Conv2D)	(None, 16, 16, 2048)	2097152	stage4_unit1_relu1[0][0]

add_31 (Add)	(None, 16, 16, 2048)	0	stage4_unit1_conv3[0][0] stage4_unit1_sc[0][0]
stage4_unit2_bn1 (BatchNormaliz	(None, 16, 16, 2048)	8192	add_31[0][0]
stage4_unit2_relu1 (Activation)	(None, 16, 16, 2048)	0	stage4_unit2_bn1[0][0]
stage4_unit2_conv1 (Conv2D)	(None, 16, 16, 512)	1048576	stage4_unit2_relu1[0][0]
stage4_unit2_bn2 (BatchNormaliz	(None, 16, 16, 512)	2048	stage4_unit2_conv1[0][0]
stage4_unit2_relu2 (Activation)	(None, 16, 16, 512)	0	stage4_unit2_bn2[0][0]
zero_padding2d_34 (ZeroPadding2	(None, 18, 18, 512)	0	stage4_unit2_relu2[0][0]
stage4_unit2_conv2 (Conv2D)	(None, 16, 16, 512)	2359296	zero_padding2d_34[0][0]
stage4_unit2_bn3 (BatchNormaliz	(None, 16, 16, 512)	2048	stage4_unit2_conv2[0][0]
stage4_unit2_relu3 (Activation)	(None, 16, 16, 512)	0	stage4_unit2_bn3[0][0]
stage4_unit2_conv3 (Conv2D)	(None, 16, 16, 2048)	1048576	stage4_unit2_relu3[0][0]
add_32 (Add)	(None, 16, 16, 2048)	0	stage4_unit2_conv3[0][0] add_31[0][0]
stage4_unit3_bn1 (BatchNormaliz	(None, 16, 16, 2048)	8192	add_32[0][0]
stage4_unit3_relu1 (Activation)	(None, 16, 16, 2048)	0	stage4_unit3_bn1[0][0]
stage4_unit3_conv1 (Conv2D)	(None, 16, 16, 512)	1048576	stage4_unit3_relu1[0][0]
stage4_unit3_bn2 (BatchNormaliz	(None, 16, 16, 512)	2048	stage4_unit3_conv1[0][0]
stage4_unit3_relu2 (Activation)	(None, 16, 16, 512)	0	stage4_unit3_bn2[0][0]
zero_padding2d_35 (ZeroPadding2	(None, 18, 18, 512)	0	stage4_unit3_relu2[0][0]
stage4_unit3_conv2 (Conv2D)	(None, 16, 16, 512)	2359296	zero_padding2d_35[0][0]
stage4_unit3_bn3 (BatchNormaliz	(None, 16, 16, 512)	2048	stage4_unit3_conv2[0][0]
stage4_unit3_relu3 (Activation)	(None, 16, 16, 512)	0	stage4_unit3_bn3[0][0]
stage4_unit3_conv3 (Conv2D)	(None, 16, 16, 2048)	1048576	stage4_unit3_relu3[0][0]
add_33 (Add)	(None, 16, 16, 2048)	0	stage4_unit3_conv3[0][0] add_32[0][0]
bn1 (BatchNormalization)	(None, 16, 16, 2048)	8192	add_33[0][0]
relu1 (Activation)	(None, 16, 16, 2048)	0	bn1[0][0]
decoder_stage0_upsampling (UpSa	(None, 32, 32, 2048)	0	relu1[0][0]
decoder_stage0_concat (Concaten	(None, 32, 32, 3072)	0	decoder_stage0_upsampling[0][0] stage4_unit1_relu1[0][0]
decoder_stage0a_conv (Conv2D)	(None, 32, 32, 256)	7077888	decoder_stage0_concat[0][0]
decoder_stage0a_bn (BatchNormal	(None, 32, 32, 256)	1024	decoder_stage0a_conv[0][0]
decoder_stage0a_relu (Activatio	(None, 32, 32, 256)	0	decoder_stage0a_bn[0][0]
decoder_stage0b_conv (Conv2D)	(None, 32, 32, 256)	589824	decoder_stage0a_relu[0][0]
decoder_stage0b_bn (BatchNormal	(None, 32, 32, 256)	1024	decoder_stage0b_conv[0][0]
decoder_stage0b_relu (Activatio	(None, 32, 32, 256)	0	decoder_stage0b_bn[0][0]
decoder_stage1_upsampling (UpSa	(None, 64, 64, 256)	0	decoder_stage0b_relu[0][0]
decoder_stage1_concat (Concaten	(None, 64, 64, 768)	0	decoder_stage1_upsampling[0][0] stage3_unit1_relu1[0][0]
decoder_stagela_conv (Conv2D)	(None, 64, 64, 128)	884736	decoder_stage1_concat[0][0]

decoder_stage1a_bn	(BatchNormal	(None, 64, 64, 128)	512	decoder_stage1a_conv[0][0]
decoder_stage1a_relu	(Activatio	(None, 64, 64, 128)	0	decoder_stage1a_bn[0][0]
decoder_stage1b_conv	(Conv2D)	(None, 64, 64, 128)	147456	decoder_stage1a_relu[0][0]
decoder_stage1b_bn	(BatchNormal	(None, 64, 64, 128)	512	decoder_stage1b_conv[0][0]
decoder_stage1b_relu	(Activatio	(None, 64, 64, 128)	0	decoder_stage1b_bn[0][0]
decoder_stage2_upsampling	(UpSa	(None, 128, 128, 128)	0	decoder_stage1b_relu[0][0]
decoder_stage2_concat	(Concaten	(None, 128, 128, 384)	0	decoder_stage2_upsampling[0][0] stage2_unit1_relu1[0][0]
decoder_stage2a_conv	(Conv2D)	(None, 128, 128, 64)	221184	decoder_stage2_concat[0][0]
decoder_stage2a_bn	(BatchNormal	(None, 128, 128, 64)	256	decoder_stage2a_conv[0][0]
decoder_stage2a_relu	(Activatio	(None, 128, 128, 64)	0	decoder_stage2a_bn[0][0]
decoder_stage2b_conv	(Conv2D)	(None, 128, 128, 64)	36864	decoder_stage2a_relu[0][0]
decoder_stage2b_bn	(BatchNormal	(None, 128, 128, 64)	256	decoder_stage2b_conv[0][0]
decoder_stage2b_relu	(Activatio	(None, 128, 128, 64)	0	decoder_stage2b_bn[0][0]
decoder_stage3_upsampling	(UpSa	(None, 256, 256, 64)	0	decoder_stage2b_relu[0][0]
decoder_stage3_concat	(Concaten	(None, 256, 256, 128)	0	decoder_stage3_upsampling[0][0] relu0[0][0]
decoder_stage3a_conv	(Conv2D)	(None, 256, 256, 32)	36864	decoder_stage3_concat[0][0]
decoder_stage3a_bn	(BatchNormal	(None, 256, 256, 32)	128	decoder_stage3a_conv[0][0]
decoder_stage3a_relu	(Activatio	(None, 256, 256, 32)	0	decoder_stage3a_bn[0][0]
decoder_stage3b_conv	(Conv2D)	(None, 256, 256, 32)	9216	decoder_stage3a_relu[0][0]
decoder_stage3b_bn	(BatchNormal	(None, 256, 256, 32)	128	decoder_stage3b_conv[0][0]
decoder_stage3b_relu	(Activatio	(None, 256, 256, 32)	0	decoder_stage3b_bn[0][0]
decoder_stage4_upsampling	(UpSa	(None, 512, 512, 32)	0	decoder_stage3b_relu[0][0]
decoder_stage4a_conv	(Conv2D)	(None, 512, 512, 16)	4608	decoder_stage4_upsampling[0][0]
decoder_stage4a_bn	(BatchNormal	(None, 512, 512, 16)	64	decoder_stage4a_conv[0][0]
decoder_stage4a_relu	(Activatio	(None, 512, 512, 16)	0	decoder_stage4a_bn[0][0]
decoder_stage4b_conv	(Conv2D)	(None, 512, 512, 16)	2304	decoder_stage4a_relu[0][0]
decoder_stage4b_bn	(BatchNormal	(None, 512, 512, 16)	64	decoder_stage4b_conv[0][0]
decoder_stage4b_relu	(Activatio	(None, 512, 512, 16)	0	decoder_stage4b_bn[0][0]
final_conv	(Conv2D)	(None, 512, 512, 3)	435	decoder_stage4b_relu[0][0]
sigmoid	(Activation)	(None, 512, 512, 3)	0	final_conv[0][0]
=====				
Total params: 51,605,756				
Trainable params: 51,505,974				
Non-trainable params: 99,782				

In [49]:

```
# final_X_train[13]
```

In [4]:

```
X_tr, X_t, Y_tr, Y_t = train_test_split(phase2_ela_aug, phase2_masks , test_size=0.3, random_state=7
```

```
)
```

In [54]:

```
Y_tr[20]
```

Out[54]:

```
'/home/ubuntu/Downloads/phase-01-training/dataset-dist/phase-01/training/phase2/mask_aug/gd_7125cec169f3635cd07db90b16e848d5.mask.png'
```

In [55]:

```
#the training doesn't even start for more points or even worse,the kernel crashes when datapoints are increased.
```

```
X_tr = X_tr[0:528]
X_t = X_t[0:528]
Y_tr = Y_tr[0:528]
Y_t = Y_t[0:528]
```

In [38]:

```
from math import ceil

batch_size=4
num_training_samples=len(X_tr)
num_validation_samples=len(X_t)
# steps = ceil(len(X_train)//batch_size)
num_epochs=20
os.makedirs('model_checkpoints')
# define callbacks for learning rate scheduling and best checkpoints saving
filepath = 'model_checkpoints/model_phase_2.hdf5'
checkpoint = keras.callbacks.ModelCheckpoint(filepath,monitor='val_metric',save_best_only=True,
mode='max')

early_stop = keras.callbacks.EarlyStopping(monitor='val_loss', patience=3)

reduce_lr = ReduceLRonPlateau(monitor = 'val_loss', factor = 0.22, patience = 1, verbose = 1, min_delta = 0.0001)
```

In []:

```
##### reduced the number of training points because system couldn't handle large arrays
```

In [39]:

```
# train model
results=model.fit_generator(loadImagesBatchwise(X_tr,Y_tr,batch_size),steps_per_epoch=(num_training_samples // batch_size), epochs=num_epochs,
                           validation_data=loadImagesBatchwise(X_t,Y_t,batch_size),validation_steps=num_validation_samples//batch_size,
                           verbose=1,callbacks=[early_stop,reduce_lr,checkpoint])
```

```
Epoch 1/20
132/132 [=====] - 1535s 12s/step - loss: 0.2919 - metric: 0.8994 - val_loss: 0.3203 - val_metric: 0.9259
Epoch 2/20
132/132 [=====] - 1513s 11s/step - loss: 0.2523 - metric: 0.9303 - val_loss: 0.2373 - val_metric: 0.9329
Epoch 3/20
132/132 [=====] - 1516s 11s/step - loss: 0.2523 - metric: 0.9301 - val_loss: 0.6006 - val_metric: 0.9483

Epoch 00003: ReduceLRonPlateau reducing learning rate to 0.00022000001044943928.
Epoch 4/20
132/132 [=====] - 1519s 12s/step - loss: 0.2505 - metric: 0.9336 - val_loss: 0.3128 - val_metric: 0.9434

Epoch 00004: ReduceLRonPlateau reducing learning rate to 4.840000357944518e-05.
Epoch 5/20
132/132 [=====] - 1514s 11s/step - loss: 0.2402 - metric: 0.9316 - val_loss: 0.3128 - val_metric: 0.9434
```

```
132/132 [=====] - 1514s 11s/step - loss: 0.2483 - metric: 0.9318 - val_loss: 0.2549 - val_metric: 0.9403
```

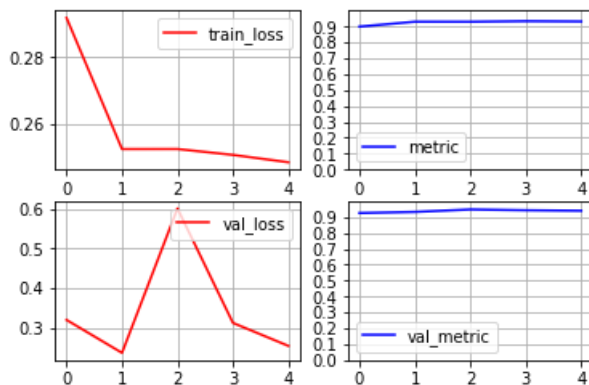
Epoch 00005: ReduceLROnPlateau reducing learning rate to 1.064800104359165e-05.

In [40]:

```
model.save('new_model_phase2.hdf5')
```

In [41]:

```
fig = plt.figure()
p1 = fig.add_subplot(221)
p2 = fig.add_subplot(222)
p3 = fig.add_subplot(223)
p4 = fig.add_subplot(224)
p2.set_ylim(0,1)
p4.set_ylim(0,1)
p1.grid()
p2.grid()
p3.grid()
p4.grid()
p2.set_yticks(np.arange(0,1,0.1))
p4.set_yticks(np.arange(0,1,0.1))
x = [i for i in range(5)]
y = results.history['loss']
y2 = results.history['metric']
y3 = results.history['val_loss']
y4 = results.history['val_metric']
p1.plot(x,y, 'r', label='train_loss')
p1.legend()
p2.plot(x,y2, 'b', label='metric')
p2.legend()
p3.plot(x,y3, 'r', label='val_loss')
p3.legend()
p4.plot(x,y4, 'b', label='val_metric')
p4.legend()
plt.show()
```



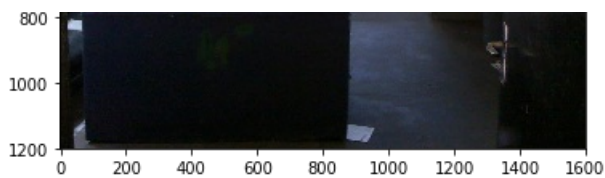
In [75]:

```
imshow(path_tampered+X_t[2][83:])
```

Out[75]:

<matplotlib.image.AxesImage at 0x7fe0fae005c0>



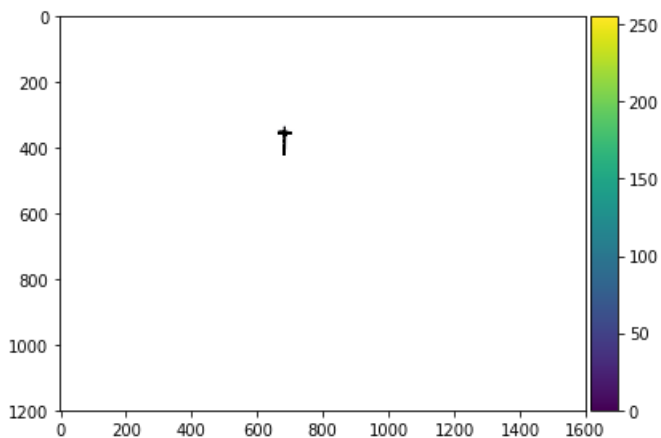


In [154]:

```
imshow(path_tampered+Y_t[2][98:])
```

Out[154]:

<matplotlib.image.AxesImage at 0x7fe0e2c525f8>



In [117]:

```
model.load_weights('model_checkpoints/model_phase_2.hdf5')
```

In [47]:

```
test_images=LoadImages(X_t)
predicted=model.predict(test_images)
```

In [246]:

```
def plot_predicted_images(index):
    """Plots the predicted masks of tampered images"""
    #ret, bw_img = cv2.threshold((predicted[index]*255),127,255,cv2.THRESH_BINARY)
    plt.imshow('pred_mask.png',predicted[index])
    im_gray = cv2.imread('pred_mask.png', cv2.IMREAD_GRAYSCALE)
    (thresh, im_bw) = cv2.threshold(im_gray, 220, 255, cv2.THRESH_BINARY | cv2.THRESH_OTSU)
    #imshow(im_bw)
    fig = plt.figure(figsize=(20,10))
    ax1 = fig.add_subplot(441)
    ax2 = fig.add_subplot(442)
    ax3 = fig.add_subplot(443)
    ax4 = fig.add_subplot(444)

    ax1.set_title("actual_image")
    ax2.set_title("actual_mask")
    ax3.set_title("predicted_mask")
    ax4.set_title("binary_predicted_mask")
    actual_img = imread(path_tampered+X_t[index][83:])

    actual_mask = imread(Y_t[index])
    #predicted_mask = imread(predicted[0])

    ax1.imshow(actual_img)
    ax2.imshow(actual_mask)
    ax3.imshow(predicted[index])
    ax4.imshow(im_bw)
```

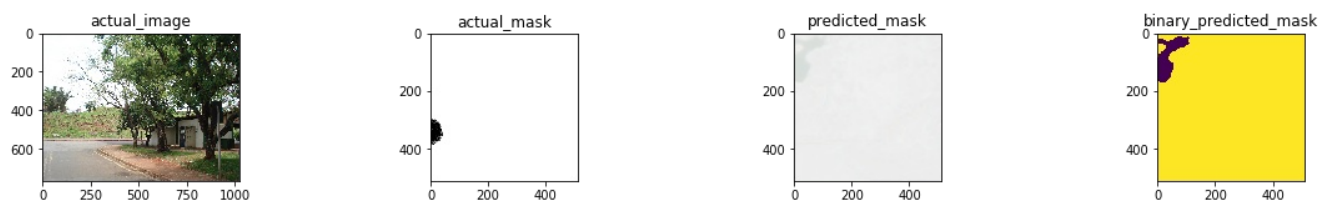
In [247]:

```
plot_predicted_images(16)
```



In [248]:

```
plot_predicted_images(1)
```



In [250]:

```
plot_predicted_images(9)
```



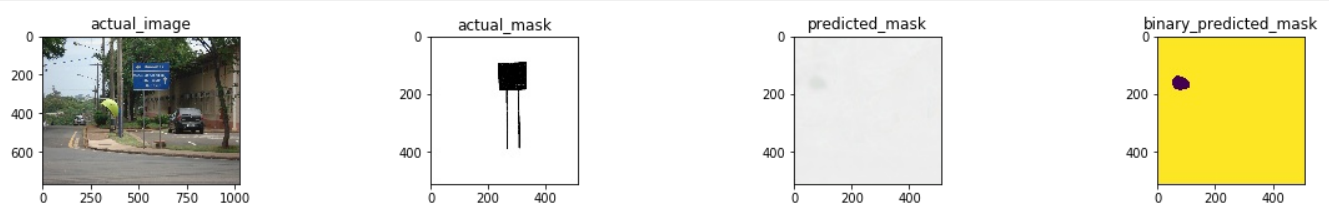
In [251]:

```
plot_predicted_images(19)
```



In [252]:

```
plot_predicted_images(40)
```



In [253]:

```
plot_predicted_images(42)
```



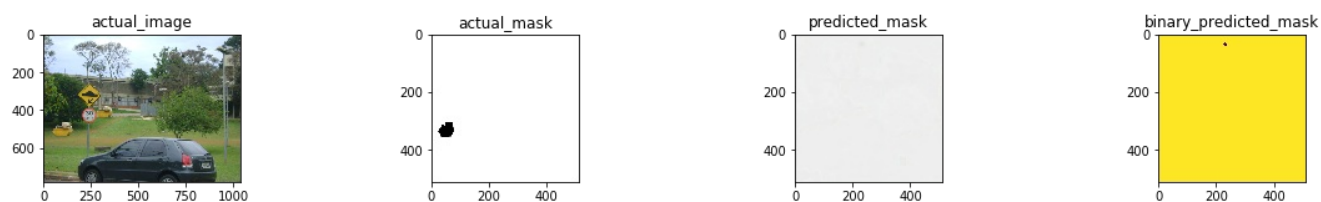
In [254]:

```
plot_predicted_images(43)
```



In [255]:

```
plot_predicted_images(48)
```



Observation and Results:

- Used less points for training because system couldn't handle large numpy arrays.
- Model's eval_metric hit 0.94 at the end of 7 epochs.
- Although the model is average, it's still able to find out in what region the tampering has happened.
- So the results are a little better than average.
- There are better techniques to find out tampered sections of the image.

In [301]:

```
# Please compare all your models using Prettytable library
# http://zetcode.com/python/prettytable/
from prettytable import PrettyTable
#If you get a ModuleNotFoundError error ,pip install prettytable

x = PrettyTable()
x.field_names = ["Metric", "Score"]

x.add_row(["Train accuracy(F score)", 0.93])
x.add_row(["Validation accuracy(F score)", 0.94])

print(x)
```

```
+-----+-----+
|          Metric          | Score |
+-----+-----+
| Train accuracy(F score)  |  0.93 |
| Validation accuracy(F score) |  0.94 |
+-----+-----+
```

In []:

In []:

In [7]:

```
# X_tr_np = np.array([imread(i) for i in tqdm(X_tr)])
```

```
100%|██████████| 5544/5544 [00:49<00:00, 155.78it/s]
```

In [8]:

```
# from numpy import save
# save('X_tr_np.npy',X_tr_np)
```

In [1]:

```
# from numpy import load
# X_tr_np = load('X_tr_np.npy')
```

In [3]:

```
# Y_tr_np = np.array([imread(i) for i in tqdm(Y_tr)])
```

```
100%|██████████| 5544/5544 [00:21<00:00, 252.07it/s]
```

In [4]:

```
# from numpy import save
# save('Y_tr_np.npy',Y_tr_np)
```

In [6]:

```
# from numpy import load
# Y_tr_np = load('Y_tr_np.npy')
```

In [5]:

```
# X_cv_np = np.array([imread(i) for i in tqdm(X_cv)])
```

```
100%|██████████| 2376/2376 [00:20<00:00, 108.61it/s]
```

In [6]:

```
# from numpy import save
# save('X_cv_np.npy',X_cv_np)
```

In [7]:

```
# from numpy import load
# X_cv_np = load('X_cv_np.npy')
```

In [7]:

```
# Y_cv_np = np.array([imread(i) for i in tqdm(Y_cv)])
```

```
100%|██████████| 2376/2376 [00:08<00:00, 264.93it/s]
```

In [8]:

```
# from numpy import save  
# save('Y_cv_np.npy',Y_cv_np)
```

In [8]:

```
# from numpy import load  
# Y_cv_np = load('Y_cv_np.npy')
```