In [1]:

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

```
Go to this URL in a browser: https://accounts.google.com/o/oauth2/auth?clien
t_id=947318989803-6bn6qk8qdgf4n4g3pfee6491hc0brc4i.apps.googleusercontent.co
m&redirect_uri=urn%3aietf%3awg%3aoauth%3a2.0%3aoob&response_type=code&scope=
email%20https%3a%2f%2fwww.googleapis.com%2fauth%2fdocs.test%20https%3a%2f%2f
www.googleapis.com%2fauth%2fdrive%20https%3a%2f%2fwww.googleapis.com%2fauth%
2fdrive.photos.readonly%20https%3a%2f%2fwww.googleapis.com%2fauth%2fpeopleap
i.readonly (https://accounts.google.com/o/oauth2/auth?client_id=947318989803
-6bn6qk8qdgf4n4g3pfee6491hc0brc4i.apps.googleusercontent.com&redirect_uri=ur
n%3aietf%3awg%3aoauth%3a2.0%3aoob&response_type=code&scope=email%20https%3a%
2f%2fwww.googleapis.com%2fauth%2fdocs.test%20https%3a%2f%2fwww.googleapis.co
m%2fauth%2fdrive%20https%3a%2f%2fwww.googleapis.com%2fauth%2fdrive.photos.re
adonly%20https%3a%2f%2fwww.googleapis.com%2fauth%2fpeopleapi.readonly)

Enter your authorization code:
··········
Mounted at /content/drive
```

In [2]:

```
import os
import sys
import random
import warnings
import pandas as pd
import pickle
from tqdm import tqdm_notebook, tqdm
from sklearn.model_selection import train_test_split
from keras.wrappers.scikit_learn import KerasClassifier
from sklearn.model_selection import cross_val_score, GridSearchCV
import seaborn as sns
from sklearn.metrics import log_loss, accuracy_score, confusion_matrix
import time
from imageio import imread
import imageio
import shutil

import tensorflow as tf
import cv2
import numpy as np
import matplotlib.pyplot as plt
from tqdm import tqdm
from itertools import chain
from skimage.io import imread, imshow, imread_collection, concatenate_images
from skimage.transform import resize
from skimage.morphology import label
from keras import optimizers
from keras.models import Model, load_model
from keras.layers.core import Dropout, Lambda
from keras.layers.convolutional import Conv2D, Conv2DTranspose
from keras.layers.merge import concatenate
from keras.callbacks import EarlyStopping, ModelCheckpoint
from keras import backend as K

import pickle
from keras.applications.vgg16 import VGG16, preprocess_input, decode_predictions
from keras.preprocessing.image import load_img, img_to_array
from keras.layers import Input, Dense, Dropout, Activation, Flatten, BatchNormalization, Co
from keras.models import Model, Sequential
from keras.layers import ZeroPadding2D
from keras.regularizers import l2

from keras.applications.resnet50 import ResNet50

import keras
```

```
Using TensorFlow backend.
```

The default version of TensorFlow in Colab will soon switch to TensorFlow 2.x.
We recommend you upgrade (https://www.tensorflow.org/guide/migrate) now or ensure your notebook will continue to use TensorFlow 1.x via the `%tensorflow_version 1.x` magic:
more info (https://colab.research.google.com/notebooks/tensorflow_version.ipynb).

In [0]:

```
path = '/content/drive/My Drive/Forensic_research/phase-01-training/dataset-dist/phase-01/t
path_drive = '/content/drive/My Drive/Forensic/AlexNet/'
```

Getting Pristine and Forged images from the Folder

In [0]:

```
fake_path = path+'fake/'
pristine_path = path+'pristine/'
```

In [0]:

```
fakes = os.listdir(fake_path)
pristines = os.listdir(pristine_path)
```

In [0]:

```
pristines_final=[]
for pristine in pristines:
#     img=imread(pristine_path+pristine)
#     if len(img.shape)<3:
#         continue
#     if img.shape[2]==4:
#         continue
    pristines_final.append(pristine_path+pristine)
```

In [0]:

```
len(pristines_final)
```

Out[7]:

```
1050
```

In [0]:

```
pristines_final[:4]
```

Out[8]:

```
['/content/drive/My Drive/Forensic_research/phase-01-training/dataset-dist/p
hase-01/training/pristine/1de0e29092a4609337372ef968046d88.png',
 '/content/drive/My Drive/Forensic_research/phase-01-training/dataset-dist/p
hase-01/training/pristine/1ae50d32e718687e82c0b8fa0607c402.png',
 '/content/drive/My Drive/Forensic_research/phase-01-training/dataset-dist/p
hase-01/training/pristine/1b4bc069995090e56ff0722033b86c9a.png',
 '/content/drive/My Drive/Forensic_research/phase-01-training/dataset-dist/p
hase-01/training/pristine/00e079b66d9e9f99892bbb81d9d6cd57.png']
```

In [0]:

```
# fake_images=[]
fakes_final=[]
for fake in fakes:
#     print(fake)
#     img=imread(fake_path+fake)
    try:
#         fake_images.append(img[:,:,:3])
        fakes_final.append(fake_path+fake)
    except IndexError:
        print(f'image {fake} has only 1 channel')
```

In [0]:

```
image_names=[]
for i in range(0, len(pristines_final)):
    image_names.append(pristines_final[i])
for i in range(0, len(fakes_final)):
    image_names.append(fakes_final[i])
```

In [0]:

```
len(image_names)
```

Out[11]:

```
1501
```

In [0]:

```
image_names.index('/content/drive/My Drive/Forensic_research/phase-01-training/dataset-dist
```

Out[12]:

```
1050
```

In [0]:

```
del image_names[1050]
```

In [0]:

```
len(image_names)
```

Out[14]:

```
1500
```

I have given pristine image as 1 and forged image as 0 to for classification of images

In [0]:

```
labels=[1]*1050+[0]*450
```

Creating train and Test image data from datset

In [0]:

```
x, x_test, y, y_test = train_test_split(image_names, labels, test_size=0.2, stratify=labels
x_train, x_cv, y_train, y_cv = train_test_split(x, y, test_size=0.2, stratify=y)
```

In [0]:

```
x_train_images = []
for image in x_train:
    try:
#         image_path = pristine_path+x
        # load an image from file
        image = load_img(image, target_size=(227, 227))
#     except FileNotFoundError:
#         image_path = fake_path+x
#         # load an image from file
#         image = load_img(image, target_size=(224, 224))
    except Exception as e:
        print(str(e))
        print(x)

    # convert the image pixels to a numpy array
    image = img_to_array(image)
    # reshape data for the model
    image = image.reshape((1, image.shape[0], image.shape[1], image.shape[2]))
    # prepare the image for the VGG model
    image = preprocess_input(image)
    x_train_images.append(image)
```

In [0]:

```
len(x_train_images)
```

Out[18]:

```
960
```

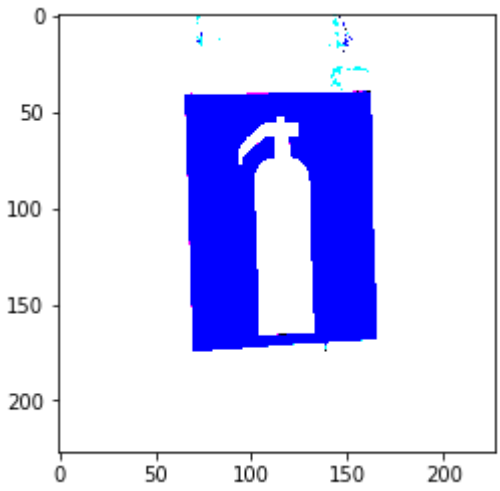
In [0]:

```
plt.imshow(x_train_images[386][0])
```

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

Out[19]:

```
<matplotlib.image.AxesImage at 0x7ff34c5b82e8>
```



In [0]:

```
x_train_images[381].shape
```

Out[23]:

```
(1, 227, 227, 3)
```

In [0]:

```
x_test_images = []
for image in x_test:
    try:
#         image_path = pristine_path+x
        # load an image from file
        image = load_img(image, target_size=(227, 227))
#     except FileNotFoundError:
#         image_path = fake_path+x
#         # load an image from file
#         image = load_img(image_path, target_size=(224, 224))
    except Exception as e:
        print(str(e))
        print(x)

    # convert the image pixels to a numpy array
    image = img_to_array(image)

#     print(image)
#     plt.imshow(image)
    # reshape data for the model
    image = image.reshape((1, image.shape[0], image.shape[1], image.shape[2]))
    # prepare the image for the VGG model
    image = preprocess_input(image)
    x_test_images.append(image)
#     break
```

In [0]:

```
x_cv_images = []
for image in x_cv:
    try:
#         image_path = pristine_path+x
        # load an image from file
        image = load_img(image, target_size=(227, 227))
#     except FileNotFoundError:
#         image_path = fake_path+x
#         # load an image from file
#         image = load_img(image_path, target_size=(224, 224))
    except Exception as e:
        print(str(e))
        print(x)

    # convert the image pixels to a numpy array
    image = img_to_array(image)

#     print(image)
#     plt.imshow(image)
    # reshape data for the model
    image = image.reshape((1, image.shape[0], image.shape[1], image.shape[2]))
    # prepare the image for the VGG model
    image = preprocess_input(image)
    x_cv_images.append(image)
```

In [0]:

```
x_train_images = np.array(x_train_images)
x_cv_images = np.array(x_cv_images)
x_test_images = np.array(x_test_images)
y_train = np.array(y_train)
y_cv = np.array(y_cv)
y_test = np.array(y_test)
```

In [0]:

```
print(x_train_images.shape)
print(x_cv_images.shape)
print(x_test_images.shape)
x_train_images = np.rollaxis(x_train_images,1,0)
x_cv_images = np.rollaxis(x_cv_images,1,0)
x_test_images = np.rollaxis(x_test_images,1,0)
print(x_train_images.shape)
print(x_cv_images.shape)
print(x_test_images.shape)
```

```
(960, 1, 227, 227, 3)
(240, 1, 227, 227, 3)
(300, 1, 227, 227, 3)
(1, 960, 227, 227, 3)
(1, 240, 227, 227, 3)
(1, 300, 227, 227, 3)
```

Type *Markdown* and LaTeX: α^2

In [0]:

```
x_train_images = x_train_images[0]
x_cv_images = x_cv_images[0]
x_test_images = x_test_images[0]
print(x_train_images.shape)
print(x_cv_images.shape)
print(x_test_images.shape)
```

In [0]:

```
import pickle
pickle_in = open(path_drive+"x_train_images.pickle","rb")
x_train_images = pickle.load(pickle_in)

pickle_in = open(path_drive+"x_cv_images.pickle","rb")
x_cv_images = pickle.load(pickle_in)

pickle_in = open(path_drive+"x_test_images.pickle","rb")
x_test_images = pickle.load(pickle_in)

pickle_in = open(path_drive+"y_train.pickle","rb")
y_train = pickle.load(pickle_in)

pickle_in = open(path_drive+"y_cv.pickle","rb")
y_cv = pickle.load(pickle_in)

pickle_in = open(path_drive+"y_test.pickle","rb")
y_test = pickle.load(pickle_in)
```

In [5]:

```
print(x_train_images.shape)
print(x_cv_images.shape)
print(x_test_images.shape)
```

```
(3572, 227, 227, 3)
(73, 227, 227, 3)
(75, 227, 227, 3)
```

Doing Feature Scaling on Image data to make all the image pixel to same pixel

In [0]:

```
x_train_images/=255
x_cv_images/=255
x_test_images/=255
```

In [0]:

```
num_classes = 1
```

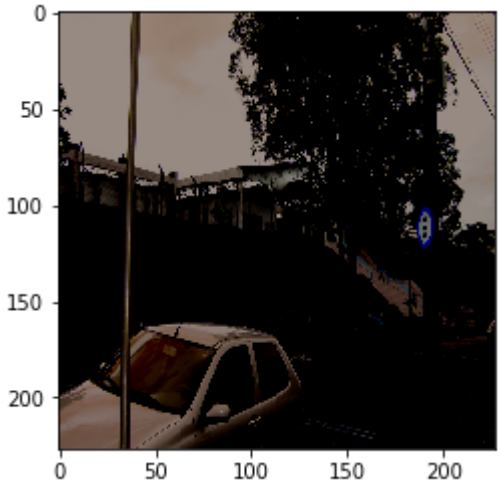
In [8]:

```
plt.imshow(x_test_images[3])
```

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

Out[8]:

```
<matplotlib.image.AxesImage at 0x7f27fe4fed68>
```



In the paper people used AlexNet Pretrained model but I was not getting pretrained features of AlexNet that is why I have used VGG16 as pretrained Model and trained AlexNet from scratch.

AlexNet Model

In [0]:

```
def alexnet_model(img_shape=(227, 227, 3), n_classes=1, l2_reg=0.,
    weights=None):

  # Initialize model
  alexnet = Sequential()

  # Layer 1
  alexnet.add(Conv2D(96, (11, 11), input_shape=img_shape, strides = (4,4)))
  alexnet.add(BatchNormalization())
  alexnet.add(Activation('relu'))
  alexnet.add(MaxPooling2D(pool_size=(3, 3), strides = (2, 2)))

  # Layer 2
  alexnet.add(ZeroPadding2D((2, 2)))
  alexnet.add(Conv2D(256, (5, 5)))
  alexnet.add(BatchNormalization())
  alexnet.add(Activation('relu'))
  alexnet.add(MaxPooling2D(pool_size=(3, 3),  strides = (2 , 2)))

  # Layer 3
  alexnet.add(ZeroPadding2D((1, 1)))
  alexnet.add(Conv2D(384, (3, 3)))
  alexnet.add(BatchNormalization())
  alexnet.add(Activation('relu'))
  # alexnet.add(MaxPooling2D(pool_size=(2, 2)))

  # Layer 4
  alexnet.add(ZeroPadding2D((1, 1)))
  alexnet.add(Conv2D(384, (3, 3)))
  # alexnet.add(BatchNormalization())
  alexnet.add(Activation('relu'))

  # Layer 5
  alexnet.add(ZeroPadding2D((1, 1)))
  alexnet.add(Conv2D(256, (3, 3)))
  # alexnet.add(BatchNormalization())
  alexnet.add(Activation('relu'))
  alexnet.add(MaxPooling2D(pool_size=(3, 3),  strides = (2, 2)))

  # Layer 6
  alexnet.add(Flatten())
  alexnet.add(Dense(4096))
  # alexnet.add(BatchNormalization())
  alexnet.add(Activation('relu'))
  alexnet.add(Dropout(0.5))

  # Layer 7
  alexnet.add(Dense(4096))
  # alexnet.add(BatchNormalization())
  alexnet.add(Activation('relu'))
  # alexnet.add(Dropout(0.5))
  alexnet.add(Dense(1000))
  # alexnet.add(BatchNormalization())
  alexnet.add(Activation('relu'))

  # Layer 8
  alexnet.add(Dense(n_classes))
  # alexnet.add(BatchNormalization())
  alexnet.add(Activation('softmax'))
```

```
  if weights is not None:
    alexnet.load_weights(weights)

  return alexnet
```

In [0]:

```
model = alexnet_model()
```

In [0]:

```
model.summary()
```

```
Model: "sequential_9"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d_41 (Conv2D)           (None, 55, 55, 96)        34944
_________________________________________________________________
batch_normalization_49 (Batc (None, 55, 55, 96)        384
_________________________________________________________________
activation_71 (Activation)   (None, 55, 55, 96)        0
_________________________________________________________________
max_pooling2d_25 (MaxPooling (None, 27, 27, 96)        0
_________________________________________________________________
zero_padding2d_13 (ZeroPaddi (None, 31, 31, 96)        0
_________________________________________________________________
conv2d_42 (Conv2D)           (None, 27, 27, 256)       614656
_________________________________________________________________
batch_normalization_50 (Batc (None, 27, 27, 256)       1024
_________________________________________________________________
activation_72 (Activation)   (None, 27, 27, 256)       0
_________________________________________________________________
max_pooling2d_26 (MaxPooling (None, 13, 13, 256)       0
_________________________________________________________________
zero_padding2d_14 (ZeroPaddi (None, 15, 15, 256)       0
_________________________________________________________________
conv2d_43 (Conv2D)           (None, 13, 13, 384)       885120
_________________________________________________________________
batch_normalization_51 (Batc (None, 13, 13, 384)       1536
_________________________________________________________________
activation_73 (Activation)   (None, 13, 13, 384)       0
_________________________________________________________________
zero_padding2d_15 (ZeroPaddi (None, 15, 15, 384)       0
_________________________________________________________________
conv2d_44 (Conv2D)           (None, 13, 13, 384)       1327488
_________________________________________________________________
activation_74 (Activation)   (None, 13, 13, 384)       0
_________________________________________________________________
zero_padding2d_16 (ZeroPaddi (None, 15, 15, 384)       0
_________________________________________________________________
conv2d_45 (Conv2D)           (None, 13, 13, 256)       884992
_________________________________________________________________
activation_75 (Activation)   (None, 13, 13, 256)       0
_________________________________________________________________
max_pooling2d_27 (MaxPooling (None, 6, 6, 256)         0
_________________________________________________________________
flatten_9 (Flatten)          (None, 9216)              0
_________________________________________________________________
dense_31 (Dense)             (None, 4096)              37752832
_________________________________________________________________
activation_76 (Activation)   (None, 4096)              0
_________________________________________________________________
dropout_21 (Dropout)         (None, 4096)              0
_________________________________________________________________
dense_32 (Dense)             (None, 4096)              16781312
_________________________________________________________________
activation_77 (Activation)   (None, 4096)              0
_________________________________________________________________
```

```
dense_33 (Dense)             (None, 1000)              4097000
_________________________________________________________________
activation_78 (Activation)   (None, 1000)              0
_________________________________________________________________
dense_34 (Dense)             (None, 1)                 1001
_________________________________________________________________
activation_79 (Activation)   (None, 1)                 0
=================================================================
Total params: 62,382,289
Trainable params: 62,380,817
Non-trainable params: 1,472
_________________________________________________________________
```

In [0]:

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

In [0]:

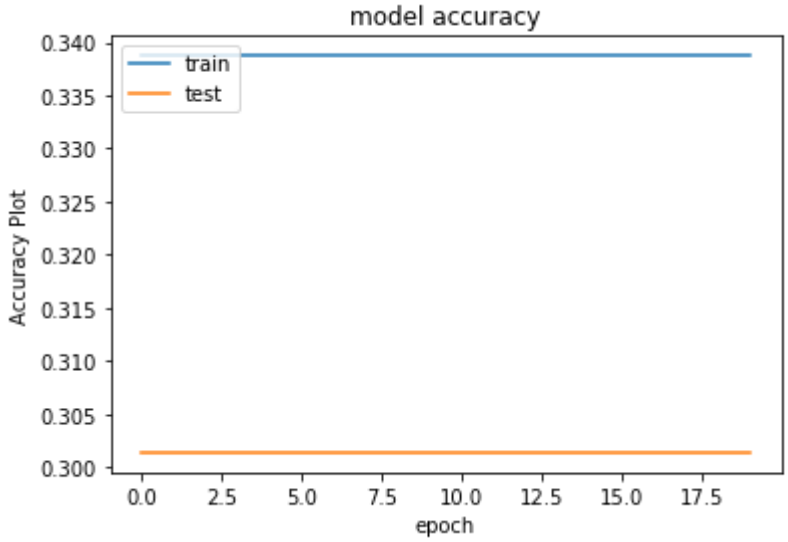
```
t = time.time()
history = model.fit(x_train_images, y_train,
          batch_size=16,
          epochs=20,
          verbose=1,
          validation_data=(x_cv_images, y_cv))
print("Training Time: %s "%(time.time()-t))
```

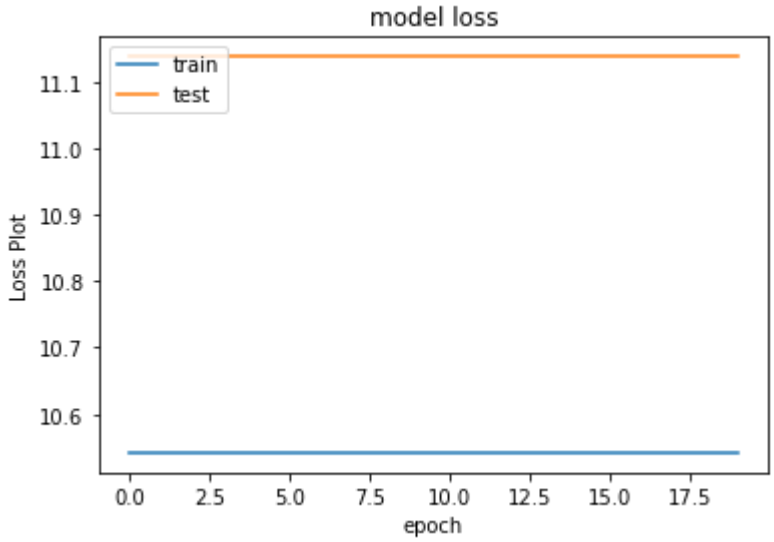
```
Train on 3572 samples, validate on 73 samples
Epoch 1/20
3572/3572 [==============================] - 13s 4ms/step - loss: 10.5420
- acc: 0.3387 - val_loss: 11.1378 - val_acc: 0.3014
Epoch 2/20
3572/3572 [==============================] - 9s 3ms/step - loss: 10.5420
- acc: 0.3387 - val_loss: 11.1378 - val_acc: 0.3014
Epoch 3/20
3572/3572 [==============================] - 9s 3ms/step - loss: 10.5420
- acc: 0.3387 - val_loss: 11.1378 - val_acc: 0.3014
Epoch 4/20
3572/3572 [==============================] - 9s 3ms/step - loss: 10.5420
- acc: 0.3387 - val_loss: 11.1378 - val_acc: 0.3014
Epoch 5/20
3572/3572 [==============================] - 9s 3ms/step - loss: 10.5420
- acc: 0.3387 - val_loss: 11.1378 - val_acc: 0.3014
Epoch 6/20
3572/3572 [==============================] - 9s 3ms/step - loss: 10.5420
- acc: 0.3387 - val_loss: 11.1378 - val_acc: 0.3014
Epoch 7/20
3572/3572 [==============================] - 9s 3ms/step - loss: 10.5420
- acc: 0.3387 - val_loss: 11.1378 - val_acc: 0.3014
Epoch 8/20
3572/3572 [==============================] - 9s 3ms/step - loss: 10.5420
- acc: 0.3387 - val_loss: 11.1378 - val_acc: 0.3014
Epoch 9/20
3572/3572 [==============================] - 9s 3ms/step - loss: 10.5420
- acc: 0.3387 - val_loss: 11.1378 - val_acc: 0.3014
Epoch 10/20
3572/3572 [==============================] - 9s 3ms/step - loss: 10.5420
- acc: 0.3387 - val_loss: 11.1378 - val_acc: 0.3014
Epoch 11/20
3572/3572 [==============================] - 9s 3ms/step - loss: 10.5420
- acc: 0.3387 - val_loss: 11.1378 - val_acc: 0.3014
Epoch 12/20
3572/3572 [==============================] - 9s 3ms/step - loss: 10.5420
- acc: 0.3387 - val_loss: 11.1378 - val_acc: 0.3014
Epoch 13/20
3572/3572 [==============================] - 9s 3ms/step - loss: 10.5420
- acc: 0.3387 - val_loss: 11.1378 - val_acc: 0.3014
Epoch 14/20
3572/3572 [==============================] - 9s 3ms/step - loss: 10.5420
- acc: 0.3387 - val_loss: 11.1378 - val_acc: 0.3014
Epoch 15/20
3572/3572 [==============================] - 9s 3ms/step - loss: 10.5420
- acc: 0.3387 - val_loss: 11.1378 - val_acc: 0.3014
Epoch 16/20
3572/3572 [==============================] - 9s 3ms/step - loss: 10.5420
- acc: 0.3387 - val_loss: 11.1378 - val_acc: 0.3014
Epoch 17/20
```

```
3572/3572 [==============================] - 9s 3ms/step - loss: 10.5420
- acc: 0.3387 - val_loss: 11.1378 - val_acc: 0.3014
Epoch 18/20
3572/3572 [==============================] - 9s 3ms/step - loss: 10.5420
- acc: 0.3387 - val_loss: 11.1378 - val_acc: 0.3014
Epoch 19/20
3572/3572 [==============================] - 9s 3ms/step - loss: 10.5420
- acc: 0.3387 - val_loss: 11.1378 - val_acc: 0.3014
Epoch 20/20
3572/3572 [==============================] - 9s 3ms/step - loss: 10.5420
- acc: 0.3387 - val_loss: 11.1378 - val_acc: 0.3014
Training Time: 188.36198019981384
```

In [0]:

```
#  "Accuracy"
plt.plot(history.history['acc'])
plt.plot(history.history['val_acc'])
plt.title('model accuracy')
plt.ylabel('Accuracy Plot')
plt.xlabel('epoch')
plt.legend(['train', 'test'], loc='upper left')
plt.show()
# "Loss"
plt.plot(history.history['loss'])
plt.plot(history.history['val_loss'])
plt.title('model loss')
plt.ylabel('Loss Plot')
plt.xlabel('epoch')
plt.legend(['train', 'test'], loc='upper left')
plt.show()
```





In [0]:

```
(loss, accuracy) = model.evaluate(x_test_images, y_test, verbose=0)

print("[INFO] loss={:.4f}, accuracy={:.4f}%".format(loss,accuracy*100))
```

```
[INFO] loss=9.9906, accuracy=37.3333%
```

In [0]:

```

```

Applied KFOLD on AlexNet To increase Accuracy

In [0]:

```
def alexnet_model(optimizer):

  # Initialize model
  alexnet = Sequential()

  # Layer 1
  alexnet.add(Conv2D(96, (11, 11), input_shape=(227,227,3), strides = (4,4)))
  alexnet.add(BatchNormalization())
  alexnet.add(Activation('relu'))
  alexnet.add(MaxPooling2D(pool_size=(3, 3), strides = (2, 2)))

  # Layer 2
  alexnet.add(ZeroPadding2D((2, 2)))
  alexnet.add(Conv2D(256, (5, 5)))
  alexnet.add(BatchNormalization())
  alexnet.add(Activation('relu'))
  alexnet.add(MaxPooling2D(pool_size=(3, 3),  strides = (2 , 2)))

  # Layer 3
  alexnet.add(ZeroPadding2D((1, 1)))
  alexnet.add(Conv2D(384, (3, 3)))
  alexnet.add(BatchNormalization())
  alexnet.add(Activation('relu'))
  # alexnet.add(MaxPooling2D(pool_size=(2, 2)))

  # Layer 4
  alexnet.add(ZeroPadding2D((1, 1)))
  alexnet.add(Conv2D(384, (3, 3)))
  # alexnet.add(BatchNormalization())
  alexnet.add(Activation('relu'))

  # Layer 5
  alexnet.add(ZeroPadding2D((1, 1)))
  alexnet.add(Conv2D(256, (3, 3)))
  # alexnet.add(BatchNormalization())
  alexnet.add(Activation('relu'))
  alexnet.add(MaxPooling2D(pool_size=(3, 3),  strides = (2, 2)))

  # Layer 6
  alexnet.add(Flatten())
  alexnet.add(Dense(4096))
  # alexnet.add(BatchNormalization())
  alexnet.add(Activation('relu'))
  alexnet.add(Dropout(0.5))

  # Layer 7
  alexnet.add(Dense(4096))
  # alexnet.add(BatchNormalization())
  alexnet.add(Activation('relu'))
  # alexnet.add(Dropout(0.5))
  alexnet.add(Dense(1000))
  # alexnet.add(BatchNormalization())
  alexnet.add(Activation('relu'))

  # Layer 8
  alexnet.add(Dense(1))
  # alexnet.add(BatchNormalization())
  alexnet.add(Activation('softmax'))
```

```
  alexnet.compile(optimizer=optimizer,
              loss='binary_crossentropy',
              metrics=['acc'])

  # if weights is not None:
  #   alexnet.load_weights(weights)

  return alexnet
```

Merging Train and Validation dataset to do KFold cross validation training

In [0]:

```
train_images = np.vstack((x_train_images,x_cv_images))
```

In [16]:

```
train_images.shape
```

Out[16]:

```
(3645, 227, 227, 3)
```

In [0]:

```
y = np.concatenate([y_train,y_cv])
```

In [15]:

```
y.shape
```

Out[15]:

```
(3645,)
```

In [0]:

```
classifier = KerasClassifier(build_fn = alexnet_model, batch_size = 10, epochs = 100)
parameter = {'batch_size':[25,32],
             'nb_epoch': [100,500],
             'optimizer':['adam', 'rmsprop', 'sgd']}

grid_search = GridSearchCV(estimator = classifier, param_grid = parameter, scoring = 'accur
grid_search = grid_search.fit(train_images, y)

best_parameters = grid_search.best_params_
best_accuracy = grid_search.best_score_
```

```
Epoch 1/100
3280/3280 [==============================] - 10s 3ms/step - loss: 10.5181
- acc: 0.3402
Epoch 2/100
3280/3280 [==============================] - 7s 2ms/step - loss: 10.5181
- acc: 0.3402
Epoch 3/100
3280/3280 [==============================] - 7s 2ms/step - loss: 10.5181
- acc: 0.3402
Epoch 4/100
3280/3280 [==============================] - 7s 2ms/step - loss: 10.5181
- acc: 0.3402
Epoch 5/100
3280/3280 [==============================] - 7s 2ms/step - loss: 10.5181
- acc: 0.3402
Epoch 6/100
3280/3280 [==============================] - 7s 2ms/step - loss: 10.5181
- acc: 0.3402
Epoch 7/100
```

From the Result we can see that we are getting only 34.62% accuracy on AlexNet Model, Not I am trying to train dataset on VGG16 pretrained model to see what accuracy we can get.

Using Pretrained VGG16 Model

In [34]:

```
vgg_model=VGG16(weights='imagenet', include_top=False, input_shape=(227,227,3))

model_aug=Sequential()
model_aug.add(vgg_model)


model = Sequential()
model.add(Conv2D(1024, kernel_size=(2, 2),
                 activation='relu',
                 input_shape=(7,7,512)))

model.add(Conv2D(512, (2, 2),
                 activation='relu'))
# model.add(MaxPooling2D(pool_size=(2, 2)))
model.add(BatchNormalization())
# model.add(Dropout(0.4))

model.add(Conv2D(512, (2, 2),
                 activation='relu'))
model.add(MaxPooling2D(pool_size=(2, 2)))
model.add(BatchNormalization())
# model.add(Dropout(0.5))

model.add(Flatten())
model.add(Dense(4096, activation='relu'))
# model.add(Dropout(0.6))
model.add(Dense(4096, activation='relu'))
# model.add(Dropout(0.6))
model.add(Dense(1024, activation='relu'))
model.add(Dense(num_classes, activation='sigmoid'))


model_aug.add(model)

model_aug.summary()
```

```
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backen
d/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 /usr/local/lib/python3.6/dist-packages/keras/backen
d/tensorflow_backend.py:148: The name tf.placeholder_with_default is depreca
ted. Please use tf.compat.v1.placeholder_with_default instead.

Model: "sequential_1"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
vgg16 (Model)                (None, 7, 7, 512)         14714688
_________________________________________________________________
sequential_2 (Sequential)    (None, 1)                 34619393
=================================================================
Total params: 49,334,081
Trainable params: 49,332,033
Non-trainable params: 2,048
_________________________________________________________________
```

In [0]:

```
for layer in model_aug.layers[0].layers[:17]:
    layer.trainable=False
# print(len(model_aug.layers[0].layers))
```

In [36]:

```
model_aug.compile(loss='binary_crossentropy', optimizer=keras.optimizers.Adam(lr=1e-4), met
```

```
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/optimiz
ers.py:793: The name tf.train.Optimizer is deprecated. Please use tf.compat.
v1.train.Optimizer instead.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backen
d/tensorflow_backend.py:3657: The name tf.log is deprecated. Please use tf.m
ath.log instead.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/tensorflow_co
re/python/ops/nn_impl.py:183: where (from tensorflow.python.ops.array_ops) i
s 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 [37]:

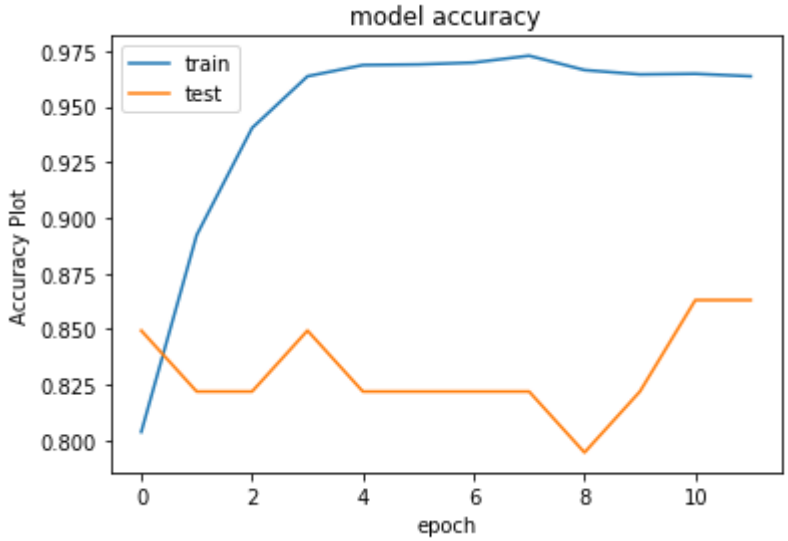
```
t = time.time()
history = model_aug.fit(x_train_images, y_train,
          batch_size=64,
          epochs=12,
          verbose=1,
          validation_data=(x_cv_images, y_cv))
print("Training Time: %s "%(t - time.time()))
```

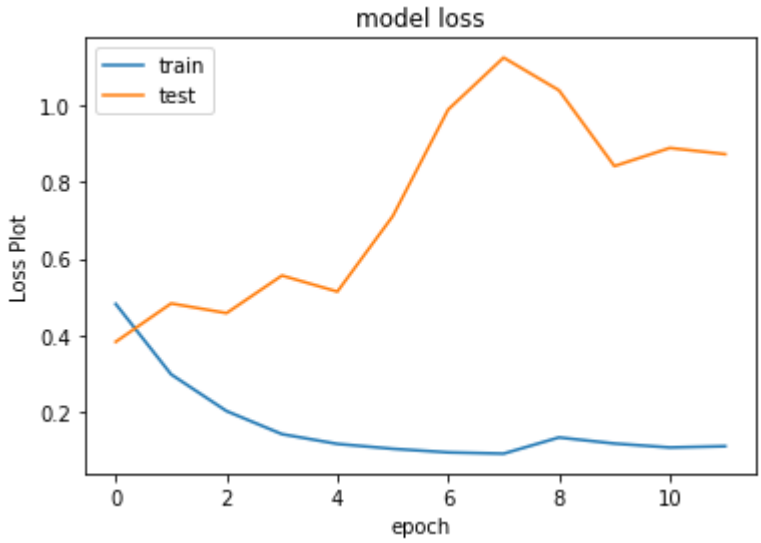
```
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backen
d/tensorflow_backend.py:1033: The name tf.assign_add is deprecated. Please u
se tf.compat.v1.assign_add instead.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backen
d/tensorflow_backend.py:1020: The name tf.assign is deprecated. Please use t
f.compat.v1.assign instead.

Train on 3572 samples, validate on 73 samples
Epoch 1/12
3572/3572 [==============================] - 16s 4ms/step - loss: 0.4820 - a
cc: 0.8038 - val_loss: 0.3831 - val_acc: 0.8493
Epoch 2/12
3572/3572 [==============================] - 11s 3ms/step - loss: 0.2981 - a
cc: 0.8922 - val_loss: 0.4833 - val_acc: 0.8219
Epoch 3/12
3572/3572 [==============================] - 11s 3ms/step - loss: 0.2024 - a
cc: 0.9404 - val_loss: 0.4581 - val_acc: 0.8219
Epoch 4/12
3572/3572 [==============================] - 11s 3ms/step - loss: 0.1422 - a
cc: 0.9636 - val_loss: 0.5562 - val_acc: 0.8493
Epoch 5/12
3572/3572 [==============================] - 11s 3ms/step - loss: 0.1167 - a
cc: 0.9686 - val_loss: 0.5142 - val_acc: 0.8219
Epoch 6/12
3572/3572 [==============================] - 11s 3ms/step - loss: 0.1039 - a
cc: 0.9689 - val_loss: 0.7112 - val_acc: 0.8219
Epoch 7/12
3572/3572 [==============================] - 11s 3ms/step - loss: 0.0945 - a
cc: 0.9698 - val_loss: 0.9894 - val_acc: 0.8219
Epoch 8/12
3572/3572 [==============================] - 11s 3ms/step - loss: 0.0913 - a
cc: 0.9728 - val_loss: 1.1250 - val_acc: 0.8219
Epoch 9/12
3572/3572 [==============================] - 11s 3ms/step - loss: 0.1335 - a
cc: 0.9664 - val_loss: 1.0396 - val_acc: 0.7945
Epoch 10/12
3572/3572 [==============================] - 11s 3ms/step - loss: 0.1177 - a
cc: 0.9644 - val_loss: 0.8418 - val_acc: 0.8219
Epoch 11/12
3572/3572 [==============================] - 11s 3ms/step - loss: 0.1074 - a
cc: 0.9647 - val_loss: 0.8892 - val_acc: 0.8630
Epoch 12/12
3572/3572 [==============================] - 11s 3ms/step - loss: 0.1107 - a
cc: 0.9636 - val_loss: 0.8730 - val_acc: 0.8630
Training Time: -138.33549284934998
```

From the accuracy curve we can see that VGG16 is giving very good accuracy on Dataset as compare to AlexNet

In [38]:

```
#  "Accuracy"
plt.plot(history.history['acc'])
plt.plot(history.history['val_acc'])
plt.title('model accuracy')
plt.ylabel('Accuracy Plot')
plt.xlabel('epoch')
plt.legend(['train', 'test'], loc='upper left')
plt.show()
# "Loss"
plt.plot(history.history['loss'])
plt.plot(history.history['val_loss'])
plt.title('model loss')
plt.ylabel('Loss Plot')
plt.xlabel('epoch')
plt.legend(['train', 'test'], loc='upper left')
plt.show()
```





In [39]:

```
(loss, accuracy) = model_aug.evaluate(x_test_images, y_test, verbose=0)
print("[INFO] loss={:.4f}, accuracy={:.4f}%".format(loss,accuracy*100))
```

```
[INFO] loss=0.8146, accuracy=88.0000%
```

In [0]:

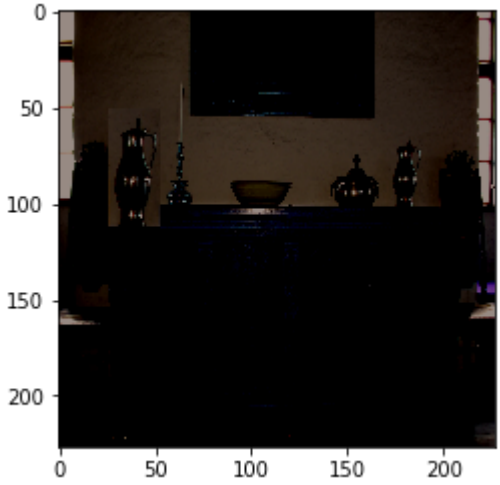
```
def prediction_value(n_cases):
  value = model_aug.predict(x_test_images[n_cases].reshape(1,227,227,3))
  plt.imshow(x_test_images[n_cases])
  if value < 0.5:
    print("Predicted Image is forged")
  else:
    print("Predicted Image is pristine")

  if y_test[n_cases] < 0.5:
    print("Actual Image is forged")
  else:
    print("Actual Image is pristine")
```

In [45]:

```
prediction_value(55)
```

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

```
Predicted Image is pristine
Actual Image is pristine
```



In [44]:

```
prediction_value(5)
```

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

Predicted Image is forged
Actual Image is forged
```

Applied SVM Classifier on VGG16 Pretrained Model

I have used Vgg16 as pretrained because I am not getting good accuracy on AlexNet Model

In [0]:

```
def vgg_model():
  vgg_model=VGG16(weights='imagenet', include_top=False, input_shape=(227,227,3))

  # model_aug.compile(loss='binary_crossentropy', optimizer=optimizer, metrics=['accuracy']

  # model_aug.summary()

  return vgg_model
```

In [11]:

```
model_vgg = vgg_model()
model_vgg.summary()
```

```
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backen
d/tensorflow_backend.py:66: The name tf.get_default_graph is deprecated. Ple
ase use tf.compat.v1.get_default_graph instead.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backen
d/tensorflow_backend.py:541: The name tf.placeholder is deprecated. Please u
se tf.compat.v1.placeholder instead.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backen
d/tensorflow_backend.py:4432: The name tf.random_uniform is deprecated. Plea
se use tf.random.uniform instead.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backen
d/tensorflow_backend.py:4267: The name tf.nn.max_pool is deprecated. Please
use tf.nn.max_pool2d instead.

Downloading data from https://github.com/fchollet/deep-learning-models/relea
ses/download/v0.1/vgg16_weights_tf_dim_ordering_tf_kernels_notop.h5 (http
s://github.com/fchollet/deep-learning-models/releases/download/v0.1/vgg16_we
ights_tf_dim_ordering_tf_kernels_notop.h5)
58892288/58889256 [==============================] - 5s 0us/step
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backen
d/tensorflow_backend.py:190: The name tf.get_default_session is deprecated.
 Please use tf.compat.v1.get_default_session instead.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backen
d/tensorflow_backend.py:197: The name tf.ConfigProto is deprecated. Please u
se tf.compat.v1.ConfigProto instead.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backen
d/tensorflow_backend.py:203: The name tf.Session is deprecated. Please use t
f.compat.v1.Session instead.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backen
d/tensorflow_backend.py:207: The name tf.global_variables is deprecated. Ple
ase use tf.compat.v1.global_variables instead.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backen
d/tensorflow_backend.py:216: The name tf.is_variable_initialized is deprecat
ed. Please use tf.compat.v1.is_variable_initialized instead.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backen
d/tensorflow_backend.py:223: The name tf.variables_initializer is deprecate
d. Please use tf.compat.v1.variables_initializer instead.

Model: "vgg16"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
input_1 (InputLayer)         (None, 227, 227, 3)       0
_________________________________________________________________
block1_conv1 (Conv2D)        (None, 227, 227, 64)      1792
_________________________________________________________________
block1_conv2 (Conv2D)        (None, 227, 227, 64)      36928
_________________________________________________________________
```

```
block1_pool (MaxPooling2D)   (None, 113, 113, 64)      0
_________________________________________________________________
block2_conv1 (Conv2D)        (None, 113, 113, 128)     73856
_________________________________________________________________
block2_conv2 (Conv2D)        (None, 113, 113, 128)     147584
_________________________________________________________________
block2_pool (MaxPooling2D)   (None, 56, 56, 128)       0
_________________________________________________________________
block3_conv1 (Conv2D)        (None, 56, 56, 256)       295168
_________________________________________________________________
block3_conv2 (Conv2D)        (None, 56, 56, 256)       590080
_________________________________________________________________
block3_conv3 (Conv2D)        (None, 56, 56, 256)       590080
_________________________________________________________________
block3_pool (MaxPooling2D)   (None, 28, 28, 256)       0
_________________________________________________________________
block4_conv1 (Conv2D)        (None, 28, 28, 512)       1180160
_________________________________________________________________
block4_conv2 (Conv2D)        (None, 28, 28, 512)       2359808
_________________________________________________________________
block4_conv3 (Conv2D)        (None, 28, 28, 512)       2359808
_________________________________________________________________
block4_pool (MaxPooling2D)   (None, 14, 14, 512)       0
_________________________________________________________________
block5_conv1 (Conv2D)        (None, 14, 14, 512)       2359808
_________________________________________________________________
block5_conv2 (Conv2D)        (None, 14, 14, 512)       2359808
_________________________________________________________________
block5_conv3 (Conv2D)        (None, 14, 14, 512)       2359808
_________________________________________________________________
block5_pool (MaxPooling2D)   (None, 7, 7, 512)         0
=================================================================
Total params: 14,714,688
Trainable params: 14,714,688
Non-trainable params: 0
_________________________________________________________________
```

In [0]:

```
import os, shutil
from keras.preprocessing.image import ImageDataGenerator

datagen = ImageDataGenerator()
batch_size = 32

def extract_features(sample_count,train, y):
    features = np.zeros(shape=(sample_count, 7, 7, 512))  # Must be equal to the output of
    labels = np.zeros(shape=(sample_count))
    # Preprocess data
    i = 0
    for x_batch, y_batch in datagen.flow(train, y, batch_size=batch_size):
        # model.fit(x_batch, y_batch)
        # batches += 1
        # if batches >= len(x_train) / 32:
    # generator = datagen.flow_from_directory(directory,
    #                                         target_size=(img_width,img_height),
    #                                         batch_size = batch_size,
    #                                         class_mode='binary')
    # Pass data through convolutional base
    # for inputs_batch, labels_batch in generator:
          features_batch = model_vgg.predict(x_batch)
          features[i * batch_size: (i + 1) * batch_size] = features_batch
          labels[i * batch_size: (i + 1) * batch_size] = y_batch
          i += 1
          if i * batch_size >= sample_count:
              break
    return features, labels
```

In [0]:

```
sample_count = train_images.shape[0]
train_features, train_labels = extract_features(sample_count, train_images, y)  # Agree wit
test_features, test_labels = extract_features(x_test_images.shape[0],x_test_images, y_test)
```

In [18]:

```
train_features.shape
```

Out[18]:

```
(3645, 7, 7, 512)
```

In [19]:

```
train_labels.shape
```

Out[19]:

```
(3645,)
```

In [40]:

```
from sklearn.svm import LinearSVC
X_train = train_features.reshape(train_features.shape[0],7*7*512)
param = [{
          "C": [0.01, 0.1, 1, 10, 100],
          "penalty":["l2"]
         }]

svm = LinearSVC(loss='squared_hinge')  # As in Tang (2013)
grid_search = GridSearchCV(svm, param, cv=10)
grid_search = grid_search.fit(X_train, train_labels)
```

```
/usr/local/lib/python3.6/dist-packages/sklearn/svm/base.py:929: Convergen
ceWarning: Liblinear failed to converge, increase the number of iteration
s.
  "the number of iterations.", ConvergenceWarning)
/usr/local/lib/python3.6/dist-packages/sklearn/svm/base.py:929: Convergen
ceWarning: Liblinear failed to converge, increase the number of iteration
s.
  "the number of iterations.", ConvergenceWarning)
/usr/local/lib/python3.6/dist-packages/sklearn/svm/base.py:929: Convergen
ceWarning: Liblinear failed to converge, increase the number of iteration
s.
  "the number of iterations.", ConvergenceWarning)
/usr/local/lib/python3.6/dist-packages/sklearn/svm/base.py:929: Convergen
ceWarning: Liblinear failed to converge, increase the number of iteration
s.
  "the number of iterations.", ConvergenceWarning)
/usr/local/lib/python3.6/dist-packages/sklearn/svm/base.py:929: Convergen
ceWarning: Liblinear failed to converge, increase the number of iteration
s.
```

In [0]:

```
import pickle
pickle_out = open(path_drive+ "sv_model.pickle","wb")
pickle.dump(grid_search, pickle_out)
pickle_out.close()
```

In [45]:

```
print('Best score for data1:', grid_search.best_score_)
```

```
Best score for data1: 0.8186556927297668
```

In [47]:

```
print('Best Kernel:',grid_search.best_estimator_)
# print('Best Gamma:',grid_search.best_estimator_)
```

```
Best Kernel: LinearSVC(C=0.01, class_weight=None, dual=True, fit_intercept=T
rue,
          intercept_scaling=1, loss='squared_hinge', max_iter=1000,
          multi_class='ovr', penalty='l2', random_state=None, tol=0.0001,
          verbose=0)
```

Loading [MathJax]/jax/output/HTML-CSS/fonts/STIX-Web/Main/Regular/Main.js

In [0]:

```
import pickle
pickle_in = open(path_drive+"sv_model.pickle","rb")
grid_search = pickle.load(pickle_in)
```

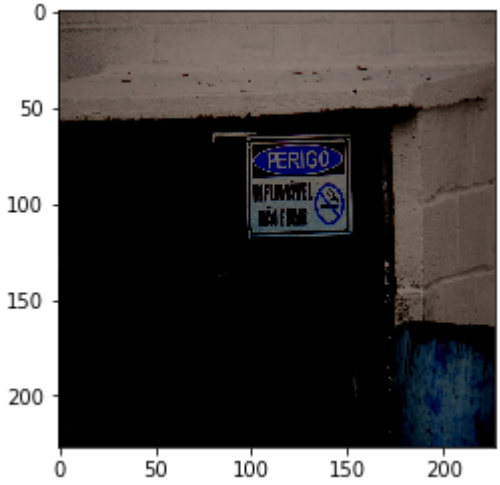
In [0]:

```
def visualize_predictions(classifier, n_cases):
  features = model_vgg.predict(x_test_images[n_cases].reshape(1,227, 227, 3))

  # Make prediction
  try:
      prediction = classifier.predict(features)
  except:
      prediction = classifier.predict(features.reshape(1, 7*7*512))

  # Show picture
  plt.imshow(x_test_images[n_cases])
  plt.show()

  # Write prediction
  if prediction < 0.5:
      print('Predicted Image as Forged')
  else:
      print('Predicted Image as Prestine')

  if y_test[n_cases] < 0.5:
      print('Actual Image is Forged')
  else:
      print('Actual Image is Prestine')
```

In [29]:

```
visualize_predictions(grid_search, 6)
```

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

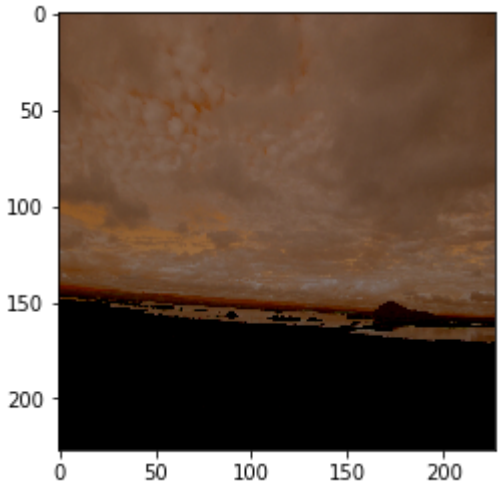



```
Predicted Image as Forged
Actual Image is Forged
```

In [30]:

```
visualize_predictions(grid_search, 10)
```

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

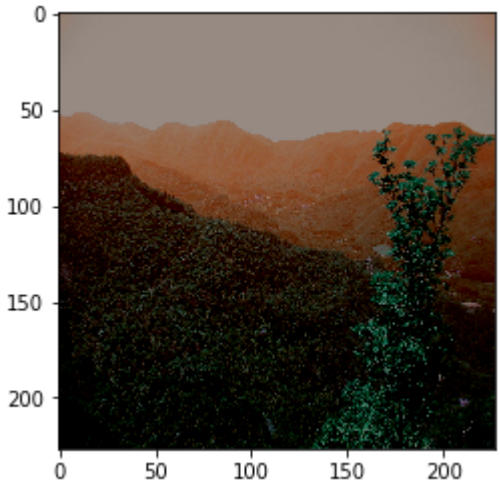



```
Predicted Image as Forged
Actual Image is Forged
```

In [31]:

```
visualize_predictions(grid_search, 16)
```

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

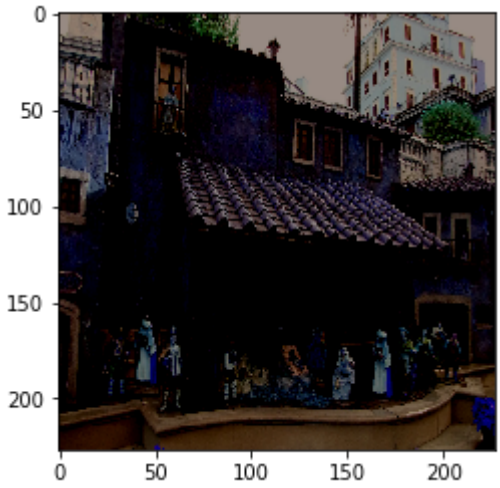



```
Predicted Image as Forged
Actual Image is Forged
```

In [33]:

```
visualize_predictions(grid_search, 66)
```

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




```
Predicted Image as Prestine
Actual Image is Prestine
```

In the paper it is mentioned that AlexNet with SVM Classifier gives good accuracy on test data but i am not getting good accuracy but VGG16 with SVM Classifier gives good accuracy but good as VGG16 with Dense layer(Softmax) classifer.

CONCLUSION :

Accuracy of Model with VGG16+ SVM Classifier 81.8%

Accuracy of model with VGG16 88%

Accuracy of model with AlexNet 34.62%

Type *Markdown* and LaTeX: α^2