In [2]:

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

```
Go to this URL in a browser: https://accounts.google.com/o/oauth2/auth?client_id=94731898
9803-6bn6qk8qdgf4n4g3pfee6491hc0brc4i.apps.googleusercontent.com&redirect_uri=urn%3aietf%
3awg%3aoauth%3a2.0%3aoob&response_type=code&scope=email%20https%3a%2f%2fwww.googleapis.co
m%2fauth%2fdocs.test%20https%3a%2f%2fwww.googleapis.com%2fauth%2fdrive%20https%3a%2f%2fww
w.googleapis.com%2fauth%2fdrive.photos.readonly%20https%3a%2f%2fwww.googleapis.com%2fauth
%2fpeopleapi.readonly

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

In [3]:

```
cd /content/drive/My Drive/AAIC/Kin
```

```
/content/drive/My Drive/AAIC/Kin
```

Recognizing Faces in the Wild (Kinship detection)

1. Business problem

1.1 Description

Blood relatives often share facial features. Now researchers at Northeastern University want to improve their algorithm for facial image classification to bridge the gap between research and other familial markers like DNA results. That will be your challenge in this new Kaggle competition.

An automatic kinship classifier has been in the works at Northeastern since 2010. Yet this technology remains largely unseen in practice for a couple of reasons:

1. **Existing image databases for kinship recognition tasks aren't large enough to capture and reflect the true data distributions of the families of the world.**
2. **Many hidden factors affect familial facial relationships, so a more discriminant model is needed than the computer vision algorithms used most often for higher-level categorizations (e.g. facial recognition or object classification).**

In 2019, North Eastern Lab conducted a competition on kaggle to get help from outside world to build a more complex model by determining if two people are blood-related based solely on images of their faces.

Problem statement

- **Predict whether two persons share kinship between them based solely on their facial images**

1.2 Real world/Business Objectives and Constraints

- **No latency requirements.**
- **Return probability scores**

2.Machine Learning Probelm

2.1 Data

2.1.1. Data Overview

- **Source:https://www.kaggle.com/c/recognizing-faces-in-the-wild/data**
- **Data provided by the NELab contains train data, test data , relationships. Train data contains pictures of people's faces along with their family and member ids. While test data simply contains pictures of random people.**

2.2 Mapping the real world problem to an ML problem

2.2.1 Type of Machine Leaning Problem

This problem can be posed as a binary classification problem with the categories being related and non-related.

2.2.2 Performance Metric

- **Area Under ROC curve**

3.Data Preprocessing and EDA

In [0]:

```
import warnings
warnings.filterwarnings("ignore")
import shutil
import os
import pandas as pd
import matplotlib
matplotlib.use(u'nbAgg')
%matplotlib inline
import matplotlib.pyplot as plt
import seaborn as sns
import numpy as np
from tqdm import tqdm
import random
from collections import defaultdict
from glob import glob
```

In [5]:

```
!pip install keras_vggface
```

```
Collecting keras_vggface
  Downloading https://files.pythonhosted.org/packages/2f/7d/5f0319ebdc09ac1a2272364fa9583
f5067b6f8aff93fbbf8835d81cbaad7/keras_vggface-0.6-py3-none-any.whl
Requirement already satisfied: keras in /usr/local/lib/python3.6/dist-packages (from kera
s_vggface) (2.2.5)
Requirement already satisfied: scipy>=0.14 in /usr/local/lib/python3.6/dist-packages (fro
m keras_vggface) (1.4.1)
Requirement already satisfied: pillow in /usr/local/lib/python3.6/dist-packages (from ker
as_vggface) (6.2.2)
Requirement already satisfied: numpy>=1.9.1 in /usr/local/lib/python3.6/dist-packages (fr
om keras_vggface) (1.17.5)
Requirement already satisfied: pyyaml in /usr/local/lib/python3.6/dist-packages (from ker
as_vggface) (3.13)
Requirement already satisfied: h5py in /usr/local/lib/python3.6/dist-packages (from keras
_vggface) (2.8.0)
Requirement already satisfied: six>=1.9.0 in /usr/local/lib/python3.6/dist-packages (from
keras_vggface) (1.12.0)
Requirement already satisfied: keras-preprocessing>=1.1.0 in /usr/local/lib/python3.6/dis
t-packages (from keras->keras_vggface) (1.1.0)
```

```
Requirement already satisfied: keras-applications>=1.0.8 in /usr/local/lib/python3.6/dist
-packages (from keras->keras_vggface) (1.0.8)
Installing collected packages: keras-vggface
Successfully installed keras-vggface-0.6
```

In [6]:

```
from __future__ import print_function
import keras
from keras.models import Sequential
from keras.layers import Dense, Dropout, Flatten
from keras.layers import Conv2D,Conv1D,Concatenate, Multiply, Subtract, Add , GlobalMaxP
ool2D, GlobalAvgPool2D, MaxPooling2D,AveragePooling2D,Average,Reshape
from keras import backend as K
from keras.models import Model
from keras.layers import Input
from keras.layers.merge import Concatenate
from keras.layers.core import Activation, Dense, Dropout, Lambda
from keras_vggface.utils import preprocess_input
from keras_vggface.vggface import VGGFace
```

```
Using TensorFlow backend.
```

The default version of TensorFlow in Colab will soon switch to TensorFlow 2.x.
We recommend you upgrade now or ensure your notebook will continue to use TensorFlow 1.x via the `%tensorflow_version 1.x` magic: more info.

In [7]:

```
#collecting all the names of images present in the train folder to a single file
images_list = glob("train/" + "*/*/*.jpg")
#creating two separate lists out of it. One for train and another one for validation
images_train_list = []
images_val_list = []
for x in tqdm(images_list):
  #as every item in the images_list is a string , if the substring 'F09' present in a cer
tain item of the images_list it falls into images_val_list.
  #So basically images which are under families starting with F09 comes under validation
set
  if 'F09' not in x:
    images_train_list.append(x)
  else:
    images_val_list.append(x)
```

```
100%|██████████| 12379/12379 [00:00<00:00, 1367429.27it/s]
```

In [8]:

```
print(len(images_train_list))
print(len(images_val_list))
```

```
11232
1147
```

In [9]:

```
fam_mem_id_all = []
#collecting family id and member id of all the images. This will be helpful later in this
notebook
for i in images_list:
  string = i.split('/')[1]+'/'+i.split('/')[2]
  fam_mem_id_all.append(string)

fam_mem_id_all[0]
```

Out[9]:

```
'F0002/MID3'
```

In [10]:

```
len(fam_mem_id_all)
len(fam_mem_id_all)
```

Out[10]:

```
12379
```

In [0]:

```
#defaultdict() is a normal dictionary (dict) but it returns a default value for a non-existent key instead of raising key error.
#The argument 'list' states that for a unique key given the dict returns a list of values
#Now 2 such dicts are created to map family member id (key) with all the images of him/her (values). One for train and another for validation data
image_dict_train = defaultdict(list)
for i in images_train_list:
   image_dict_train[i.split("/")[1] + "/" + i.split("/")[2]].append(i)
```

In [0]:

```
image_dict_val = defaultdict(list)
for i in images_val_list:
   image_dict_val[i.split("/")[1] + "/" + i.split("/")[2]].append(i)
```

In [13]:

```
print(len(image_dict_train))
print(len(image_dict_val))
```

```
2085
231
```

In [14]:

```
[v for v in list(image_dict_train.values())[:3]]
```

Out[14]:

```
[['train/F0002/MID3/P00011_face3.jpg',
  'train/F0002/MID3/P00013_face3.jpg',
  'train/F0002/MID3/P00014_face1.jpg',
  'train/F0002/MID3/P00015_face1.jpg',
  'train/F0002/MID3/P00009_face1.jpg',
  'train/F0002/MID3/P00010_face1.jpg',
  'train/F0002/MID3/P00018_face2.jpg',
  'train/F0002/MID3/P00017_face1.jpg'],
 ['train/F0002/MID1/P00016_face2.jpg',
  'train/F0002/MID1/P00009_face3.jpg',
  'train/F0002/MID1/P00015_face2.jpg',
  'train/F0002/MID1/P00012_face2.jpg',
  'train/F0002/MID1/P00013_face2.jpg',
  'train/F0002/MID1/P00017_face3.jpg',
  'train/F0002/MID1/P00011_face1.jpg',
  'train/F0002/MID1/P00014_face2.jpg',
  'train/F0002/MID1/P00010_face4.jpg',
  'train/F0002/MID1/P00018_face1.jpg'],
 ['train/F0002/MID2/P00012_face1.jpg',
  'train/F0002/MID2/P00011_face2.jpg',
  'train/F0002/MID2/P00010_face3.jpg',
  'train/F0002/MID2/P00013_face1.jpg',
  'train/F0002/MID2/P00016_face1.jpg',
  'train/F0002/MID2/P00017_face2.jpg',
  'train/F0002/MID2/P00015_face4.jpg',
  'train/F0002/MID2/P00009_face2.jpg',
  'train/F0002/MID2/P00018_face3.jpg']]
```

In [0]:

```
data_df = pd.read_csv('train_relationships.csv')
#zip to zip each pair in the data. When iteration is done through it , it iterates through pairs
data_df_pair_list = list(zip(data_df['p1'].values, data_df['p2'].values))
#getting those pairs which are actually present in the data. Some of them are missing.fam
```

```
_mem_id_all contains all the ids/folders that are present in the data.
all_present_pair_list = []
for i in data_df_pair_list:
  if i[0] in fam_mem_id_all and i[1] in fam_mem_id_all:
    all_present_pair_list.append(i)
```

In [0]:

```
train_pairs = []
val_pairs = []
#creating tuples which are kins
for i in all_present_pair_list:
  if 'F09' not in i[0]:
    train_pairs.append(i)
  else:
    val_pairs.append(i)
```

In [17]:

```
print(len(train_pairs))
print(len(val_pairs))
```

```
3066
296
```

In [18]:

```
train_pairs[0:3]
```

Out[18]:

```
[('F0002/MID1', 'F0002/MID3'),
 ('F0002/MID2', 'F0002/MID3'),
 ('F0005/MID1', 'F0005/MID2')]
```

In [19]:

```
val_pairs[0:3]
```

Out[19]:

```
[('F0900/MID2', 'F0900/MID1'),
 ('F0900/MID3', 'F0900/MID1'),
 ('F0901/MID1', 'F0901/MID4')]
```

In [0]:

```
# code credits https://github.com/nyoki-mtl/keras-facenet/blob/master/notebook/demo-image
s.ipynb
# 2 pretrained face models are used to build the model. Facenet and vgg face -resnet 50
# prewhiten is a image preprocessing function related to facenet.It returns preprocessed
images that are fed as input to facenet.

def prewhiten(x):
    if x.ndim == 4:
        axis = (1, 2, 3)
        size = x[0].size
    elif x.ndim == 3:
        axis = (0, 1, 2)
        size = x.size
    else:
        raise ValueError('Dimension should be 3 or 4')

    mean = np.mean(x, axis=axis, keepdims=True)
    std = np.std(x, axis=axis, keepdims=True)
    std_adj = np.maximum(std, 1.0/np.sqrt(size))
    y = (x - mean) / std_adj
    return y
```

In [0]:

```
#A helper function to fetch preprocessed images for facenet
```

```
import cv2
def getimage_fn(path):
    img = cv2.imread(path)
    img = cv2.resize(img,(160,160))
    img = np.array(img).astype(np.float)
    return prewhiten(img)
```

In [0]:

```
# A helper function to fetch preprocessed images for vgg model
from keras_vggface.utils import preprocess_input
def getimage_vgg(path):
    img = cv2.imread(path)
    img = cv2.resize(img,(224,224))
    img = np.array(img).astype(np.float)
    return preprocess_input(img, version=2)
```

In [0]:

```
# generator to generate a batch of data tuples
# code inspired from https://medium.com/analytics-vidhya/kinship-classification-using-vgg
face-a7c76f81288
def generator(data_list, data_dict, batch_size=16):
    data_members = list(data_dict.keys())
    #This generator should have a infinite loop so that it can yield batches as long as t
he fit_generator method is running
    while 1:
        sample_list = random.sample(data_list, batch_size // 2)
        l = [1] * len(sample_list)
        while len(sample_list) < batch_size:
            p1 = random.choice(data_members)
            p2 = random.choice(data_members)

            if p1 != p2 and (p1, p2) not in data_list and (p2, p1) not in data_list:
                sample_list.append((p1, p2))
                l.append(0)

        for i in sample_list:
            if not len(data_dict[i[0]]):
                print(i[0])

        X1 = [random.choice(data_dict[x[0]]) for x in sample_list]
        image_fn_1 = np.array([getimage_fn(x) for x in X1])
        image_vgg_1 = np.array([getimage_vgg(x) for x in X1])

        X2 = [random.choice(data_dict[x[1]]) for x in sample_list]
        image_fn_2 = np.array([getimage_fn(x) for x in X2])
        image_vgg_2 = np.array([getimage_vgg(x) for x in X2])

        yield [image_vgg_1,image_vgg_2,image_fn_1,image_fn_2], l
```

In [0]:

```
#building model
pre_face = VGGFace(model='resnet50', include_top=False)
for x in pre_face.layers[:-3]:
    x.trainable = True

from keras.models import load_model
face_net = load_model('facenet_keras.h5')
for layer in face_net.layers:
    layer.trainable = True

image_1_vgg = Input(shape=(224, 224, 3))
image_2_vgg = Input(shape=(224, 224, 3))
image_1_fn = Input(shape=(160, 160, 3))
image_2_fn = Input(shape=(160, 160, 3))

out_1_vgg = pre_face(image_1_vgg)
out_2_vgg = pre_face(image_2_vgg)
out_1_fn = face_net(image_1_fn)
```

```python
out_2_fn = face_net(image_2_fn)

gmax_Avg_vgg1 = out_1_vgg
gmax_Avg_vgg2 = out_2_vgg
out_1_fn_rs = Reshape((1, 1 ,128))(out_1_fn)
out_2_fn_rs = Reshape((1, 1 ,128))(out_2_fn)
gmax_Avg_fn1 = Concatenate(axis=-1)([GlobalMaxPool2D()(out_1_fn_rs), GlobalAvgPool2D()(out_1_fn_rs)])
gmax_Avg_fn2 = Concatenate(axis=-1)([GlobalMaxPool2D()(out_2_fn_rs), GlobalAvgPool2D()(out_2_fn_rs)])

#gmax_Avg_vgg1 = Concatenate(axis=-1)([GlobalMaxPool2D()(out_1_vgg), GlobalAvgPool2D()(out_1_vgg)])
#gmax_Avg_vgg2 = Concatenate(axis=-1)([GlobalMaxPool2D()(out_2_vgg), GlobalAvgPool2D()(out_2_vgg)])


add_fn = Add()([gmax_Avg_fn1 , gmax_Avg_fn2])
add_vgg = Add()([gmax_Avg_vgg1 , gmax_Avg_vgg2])
sub_fn = Subtract()([gmax_Avg_fn1,gmax_Avg_fn2])
sub_vgg = Subtract()([gmax_Avg_vgg1,gmax_Avg_vgg2])
mul_fn = Multiply()([gmax_Avg_fn1,gmax_Avg_fn2])
mul_vgg = Multiply()([gmax_Avg_vgg1,gmax_Avg_vgg2])
avg_fn = Average()([gmax_Avg_fn1,gmax_Avg_fn2])
avg_vgg = Average()([gmax_Avg_vgg1,gmax_Avg_vgg2])

conv_add_vgg = Conv2D(128 , [1,1] )(add_vgg)
conv_sub_vgg = Conv2D(128 , [1,1] )(sub_vgg)
conv_mul_vgg = Conv2D(128 , [1,1] )(mul_vgg)
conv_avg_vgg = Conv2D(128 , [1,1] )(avg_vgg)

all_fs = Concatenate(axis=-1)([Flatten()(conv_add_vgg), (add_fn), Flatten()(conv_sub_vgg), (sub_fn),
                                   Flatten()(conv_mul_vgg), (mul_fn),Flatten()(conv_avg_vgg), (avg_fn)])


d1 = Dense(100, activation="relu")(all_fs)
do1 = Dropout(0.1)(d1)
d2 = Dense(32, activation="relu")(do1)
do2 = Dropout(0.1)(d2)
out = Dense(1, activation="sigmoid")(do2)

model = Model([image_1_vgg, image_2_vgg, image_1_fn, image_2_fn], out)
```

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

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

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

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

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

```
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorflow_b
ackend.py:216: The name tf.is_variable_initialized is deprecated. Please use tf.compat.v1
.is_variable_initialized instead.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorflow_b
ackend.py:223: The name tf.variables_initializer is deprecated. Please use tf.compat.v1.v
ariables_initializer instead.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorflow_b
ackend.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/backend/tensorflow_b
ackend.py:148: The name tf.placeholder_with_default is deprecated. Please use tf.compat.v
1.placeholder_with_default instead.

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

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorflow_b
ackend.py:4271: The name tf.nn.avg_pool is deprecated. Please use tf.nn.avg_pool2d instea
d.

Downloading data from https://github.com/rcmalli/keras-vggface/releases/download/v2.0/rcm
alli_vggface_tf_notop_resnet50.h5
94699520/94694792 [==============================] - 2s 0us/step
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorflow_b
ackend.py:3733: calling dropout (from tensorflow.python.ops.nn_ops) with keep_prob is dep
recated and will be removed in a future version.
Instructions for updating:
Please use `rate` instead of `keep_prob`. Rate should be set to `rate = 1 - keep_prob`.
```

In [0]:

```
model.summary()
```

```
Model: "model_1"
_________________________________________________________________________________________
_________
Layer (type)                    Output Shape         Param #     Connected to

=========================================================================================
=========
input_4 (InputLayer)            (None, 160, 160, 3)  0


_________________________________________________________________________________________
_________
input_5 (InputLayer)            (None, 160, 160, 3)  0


_________________________________________________________________________________________
_________
input_2 (InputLayer)            (None, 224, 224, 3)  0


_________________________________________________________________________________________
_________
input_3 (InputLayer)            (None, 224, 224, 3)  0


_________________________________________________________________________________________
_________
inception_resnet_v1 (Model)     (None, 128)          22808144    input_4[0][0]

                                                                 input_5[0][0]


_________________________________________________________________________________________
_________
vggface_resnet50 (Model)        multiple             23561152    input_2[0][0]

                                                                 input_3[0][0]


_________________________________________________________________________________________
```

```
_________
reshape_1 (Reshape)             (None, 1, 1, 128)    0           inception_resnet_v1[1][
0]

_________________________________________________________________________________________
_________
reshape_2 (Reshape)             (None, 1, 1, 128)    0           inception_resnet_v1[2][
0]

_________________________________________________________________________________________
_________
add_18 (Add)                    (None, 1, 1, 2048)   0           vggface_resnet50[1][0]

                                                                 vggface_resnet50[2][0]


_________________________________________________________________________________________
_________
global_max_pooling2d_1 (GlobalM (None, 128)          0           reshape_1[0][0]


_________________________________________________________________________________________
_________
global_average_pooling2d_1 (Glo (None, 128)          0           reshape_1[0][0]


_________________________________________________________________________________________
_________
global_max_pooling2d_2 (GlobalM (None, 128)          0           reshape_2[0][0]


_________________________________________________________________________________________
_________
global_average_pooling2d_2 (Glo (None, 128)          0           reshape_2[0][0]


_________________________________________________________________________________________
_________
subtract_2 (Subtract)           (None, 1, 1, 2048)   0           vggface_resnet50[1][0]

                                                                 vggface_resnet50[2][0]


_________________________________________________________________________________________
_________
multiply_2 (Multiply)           (None, 1, 1, 2048)   0           vggface_resnet50[1][0]

                                                                 vggface_resnet50[2][0]


_________________________________________________________________________________________
_________
average_2 (Average)             (None, 1, 1, 2048)   0           vggface_resnet50[1][0]

                                                                 vggface_resnet50[2][0]


_________________________________________________________________________________________
_________
conv2d_1 (Conv2D)               (None, 1, 1, 128)    262272      add_18[0][0]


_________________________________________________________________________________________
_________
concatenate_1 (Concatenate)     (None, 256)          0           global_max_pooling2d_1[
0][0]
                                                                 global_average_pooling
2d_1[0][0]
_________________________________________________________________________________________
_________
concatenate_2 (Concatenate)     (None, 256)          0           global_max_pooling2d_2[
0][0]
                                                                 global_average_pooling
2d_2[0][0]
_________________________________________________________________________________________
_________
conv2d_2 (Conv2D)               (None, 1, 1, 128)    262272      subtract_2[0][0]


_________________________________________________________________________________________
_________
conv2d_3 (Conv2D)               (None, 1, 1, 128)    262272      multiply_2[0][0]


_________________________________________________________________________________________
```

```
_________
conv2d_4 (Conv2D)               (None, 1, 1, 128)    262272      average_2[0][0]

_________________________________________________________________________________________
_________
flatten_1 (Flatten)             (None, 128)          0           conv2d_1[0][0]

_________________________________________________________________________________________
_________
add_17 (Add)                    (None, 256)          0           concatenate_1[0][0]

                                                                 concatenate_2[0][0]

_________________________________________________________________________________________
_________
flatten_2 (Flatten)             (None, 128)          0           conv2d_2[0][0]

_________________________________________________________________________________________
_________
subtract_1 (Subtract)           (None, 256)          0           concatenate_1[0][0]

                                                                 concatenate_2[0][0]

_________________________________________________________________________________________
_________
flatten_3 (Flatten)             (None, 128)          0           conv2d_3[0][0]

_________________________________________________________________________________________
_________
multiply_1 (Multiply)           (None, 256)          0           concatenate_1[0][0]

                                                                 concatenate_2[0][0]

_________________________________________________________________________________________
_________
flatten_4 (Flatten)             (None, 128)          0           conv2d_4[0][0]

_________________________________________________________________________________________
_________
average_1 (Average)             (None, 256)          0           concatenate_1[0][0]

                                                                 concatenate_2[0][0]

_________________________________________________________________________________________
_________
concatenate_3 (Concatenate)     (None, 1536)         0           flatten_1[0][0]

                                                                 add_17[0][0]

                                                                 flatten_2[0][0]

                                                                 subtract_1[0][0]

                                                                 flatten_3[0][0]

                                                                 multiply_1[0][0]

                                                                 flatten_4[0][0]

                                                                 average_1[0][0]

_________________________________________________________________________________________
_________
dense_1 (Dense)                 (None, 100)          153700      concatenate_3[0][0]

_________________________________________________________________________________________
_________
dropout_1 (Dropout)             (None, 100)          0           dense_1[0][0]

_________________________________________________________________________________________
_________
dense_2 (Dense)                 (None, 32)           3232        dropout_1[0][0]
```

```
__________________________________________________________________________________________________
__________
dropout_2 (Dropout)             (None, 32)          0           dense_2[0][0]

__________________________________________________________________________________________________
__________
dense_3 (Dense)                 (None, 1)           33          dropout_2[0][0]

==================================================================================================
=========
Total params: 47,575,349
Trainable params: 47,493,397
Non-trainable params: 81,952
__________________________________________________________________________________________________
__________
```

In [0]:

```
from keras.optimizers import Adam
from keras.losses import binary_crossentropy
model.compile(loss="binary_crossentropy",optimizer=Adam(0.00001),metrics=['acc'])
```

In [0]:

```
import threading
from keras.callbacks import ReduceLROnPlateau
lr = ReduceLROnPlateau(monitor='val_acc', mode='max',patience=10,factor=0.5,verbose=1)
from keras.callbacks import ModelCheckpoint
ckpt = ModelCheckpoint('fn_vgg_new.h5', mode='max', verbose=1,monitor='val_acc', save_be
st_only= True)
```

In [0]:

```
inspect = model.fit_generator(generator(train_pairs, image_dict_train, batch_size=16), u
se_multiprocessing=True,
                     validation_data=generator(val_pairs, image_dict_val, batch_size=16),
epochs=40, verbose=1,
                     workers = 4, callbacks=[lr, ckpt], steps_per_epoch=200, validation_s
teps=100)
```

```
Epoch 1/40
200/200 [==============================] - 604s 3s/step - loss: 0.8244 - acc: 0.5697 - va
l_loss: 0.7347 - val_acc: 0.5938

Epoch 00001: val_acc improved from -inf to 0.59375, saving model to fn_vgg_new.h5
Epoch 2/40
200/200 [==============================] - 264s 1s/step - loss: 0.6714 - acc: 0.6181 - va
l_loss: 0.6438 - val_acc: 0.6475

Epoch 00002: val_acc improved from 0.59375 to 0.64750, saving model to fn_vgg_new.h5
Epoch 3/40
200/200 [==============================] - 216s 1s/step - loss: 0.6186 - acc: 0.6738 - va
l_loss: 0.6196 - val_acc: 0.6713

Epoch 00003: val_acc improved from 0.64750 to 0.67125, saving model to fn_vgg_new.h5
Epoch 4/40
200/200 [==============================] - 215s 1s/step - loss: 0.5805 - acc: 0.6816 - va
l_loss: 0.5748 - val_acc: 0.6937

Epoch 00004: val_acc improved from 0.67125 to 0.69375, saving model to fn_vgg_new.h5
Epoch 5/40
200/200 [==============================] - 215s 1s/step - loss: 0.5616 - acc: 0.6972 - va
l_loss: 0.5808 - val_acc: 0.6850

Epoch 00005: val_acc did not improve from 0.69375
Epoch 6/40
200/200 [==============================] - 216s 1s/step - loss: 0.5277 - acc: 0.7269 - va
l_loss: 0.5558 - val_acc: 0.7087

Epoch 00006: val_acc improved from 0.69375 to 0.70875, saving model to fn_vgg_new.h5
Epoch 7/40
```

```
200/200 [==============================] - 214s 1s/step - loss: 0.5233 - acc: 0.7359 - va
l_loss: 0.5425 - val_acc: 0.7219

Epoch 00007: val_acc improved from 0.70875 to 0.72188, saving model to fn_vgg_new.h5
Epoch 8/40
200/200 [==============================] - 214s 1s/step - loss: 0.5115 - acc: 0.7394 - va
l_loss: 0.5230 - val_acc: 0.7394

Epoch 00008: val_acc improved from 0.72188 to 0.73938, saving model to fn_vgg_new.h5
Epoch 9/40
200/200 [==============================] - 213s 1s/step - loss: 0.4756 - acc: 0.7700 - va
l_loss: 0.5391 - val_acc: 0.7344

Epoch 00009: val_acc did not improve from 0.73938
Epoch 10/40
200/200 [==============================] - 215s 1s/step - loss: 0.4808 - acc: 0.7675 - va
l_loss: 0.5162 - val_acc: 0.7538

Epoch 00010: val_acc improved from 0.73938 to 0.75375, saving model to fn_vgg_new.h5
Epoch 11/40
200/200 [==============================] - 214s 1s/step - loss: 0.4514 - acc: 0.7947 - va
l_loss: 0.4695 - val_acc: 0.7744

Epoch 00011: val_acc improved from 0.75375 to 0.77438, saving model to fn_vgg_new.h5
Epoch 12/40
200/200 [==============================] - 214s 1s/step - loss: 0.4470 - acc: 0.7894 - va
l_loss: 0.4864 - val_acc: 0.7656

Epoch 00012: val_acc did not improve from 0.77438
Epoch 13/40
200/200 [==============================] - 215s 1s/step - loss: 0.4297 - acc: 0.7847 - va
l_loss: 0.4833 - val_acc: 0.7725

Epoch 00013: val_acc did not improve from 0.77438
Epoch 14/40
200/200 [==============================] - 215s 1s/step - loss: 0.4101 - acc: 0.8044 - va
l_loss: 0.4681 - val_acc: 0.7775

Epoch 00014: val_acc improved from 0.77438 to 0.77750, saving model to fn_vgg_new.h5
Epoch 15/40
200/200 [==============================] - 213s 1s/step - loss: 0.4253 - acc: 0.7984 - va
l_loss: 0.5056 - val_acc: 0.7619

Epoch 00015: val_acc did not improve from 0.77750
Epoch 16/40
200/200 [==============================] - 215s 1s/step - loss: 0.4156 - acc: 0.8022 - va
l_loss: 0.5289 - val_acc: 0.7619

Epoch 00016: val_acc did not improve from 0.77750
Epoch 17/40
200/200 [==============================] - 214s 1s/step - loss: 0.3938 - acc: 0.8219 - va
l_loss: 0.4613 - val_acc: 0.7812

Epoch 00017: val_acc improved from 0.77750 to 0.78125, saving model to fn_vgg_new.h5
Epoch 18/40
200/200 [==============================] - 216s 1s/step - loss: 0.4093 - acc: 0.8122 - va
l_loss: 0.5032 - val_acc: 0.7788

Epoch 00018: val_acc did not improve from 0.78125
Epoch 19/40
200/200 [==============================] - 217s 1s/step - loss: 0.3963 - acc: 0.8216 - va
l_loss: 0.4865 - val_acc: 0.7669

Epoch 00019: val_acc did not improve from 0.78125
Epoch 20/40
200/200 [==============================] - 217s 1s/step - loss: 0.3627 - acc: 0.8341 - va
l_loss: 0.4635 - val_acc: 0.7819

Epoch 00020: val_acc improved from 0.78125 to 0.78187, saving model to fn_vgg_new.h5
Epoch 21/40
200/200 [==============================] - 215s 1s/step - loss: 0.3782 - acc: 0.8353 - va
l_loss: 0.4874 - val_acc: 0.7688
```

```
Epoch 00021: val_acc did not improve from 0.78187
Epoch 22/40
200/200 [==============================] - 216s 1s/step - loss: 0.3525 - acc: 0.8422 - va
l_loss: 0.4851 - val_acc: 0.7644

Epoch 00022: val_acc did not improve from 0.78187
Epoch 23/40
200/200 [==============================] - 216s 1s/step - loss: 0.3564 - acc: 0.8394 - va
l_loss: 0.4470 - val_acc: 0.7806

Epoch 00023: val_acc did not improve from 0.78187
Epoch 24/40
200/200 [==============================] - 216s 1s/step - loss: 0.3477 - acc: 0.8481 - va
l_loss: 0.4567 - val_acc: 0.7812

Epoch 00024: val_acc did not improve from 0.78187
Epoch 25/40
200/200 [==============================] - 216s 1s/step - loss: 0.3644 - acc: 0.8406 - va
l_loss: 0.4618 - val_acc: 0.7731

Epoch 00025: val_acc did not improve from 0.78187
Epoch 26/40
200/200 [==============================] - 216s 1s/step - loss: 0.3382 - acc: 0.8509 - va
l_loss: 0.4234 - val_acc: 0.8000

Epoch 00026: val_acc improved from 0.78187 to 0.80000, saving model to fn_vgg_new.h5
Epoch 27/40
200/200 [==============================] - 215s 1s/step - loss: 0.3498 - acc: 0.8509 - va
l_loss: 0.4530 - val_acc: 0.7969

Epoch 00027: val_acc did not improve from 0.80000
Epoch 28/40
200/200 [==============================] - 217s 1s/step - loss: 0.3349 - acc: 0.8556 - va
l_loss: 0.4728 - val_acc: 0.7781

Epoch 00028: val_acc did not improve from 0.80000
Epoch 29/40
200/200 [==============================] - 216s 1s/step - loss: 0.3228 - acc: 0.8603 - va
l_loss: 0.4892 - val_acc: 0.7762

Epoch 00029: val_acc did not improve from 0.80000
Epoch 30/40
200/200 [==============================] - 217s 1s/step - loss: 0.3114 - acc: 0.8703 - va
l_loss: 0.4944 - val_acc: 0.7706

Epoch 00030: val_acc did not improve from 0.80000
Epoch 31/40
200/200 [==============================] - 216s 1s/step - loss: 0.3220 - acc: 0.8616 - va
l_loss: 0.5484 - val_acc: 0.7700

Epoch 00031: val_acc did not improve from 0.80000
Epoch 32/40
200/200 [==============================] - 216s 1s/step - loss: 0.3218 - acc: 0.8619 - va
l_loss: 0.4650 - val_acc: 0.7887

Epoch 00032: val_acc did not improve from 0.80000
Epoch 33/40
200/200 [==============================] - 216s 1s/step - loss: 0.3099 - acc: 0.8672 - va
l_loss: 0.4484 - val_acc: 0.8037

Epoch 00033: val_acc improved from 0.80000 to 0.80375, saving model to fn_vgg_new.h5
Epoch 34/40
200/200 [==============================] - 215s 1s/step - loss: 0.3142 - acc: 0.8669 - va
l_loss: 0.5021 - val_acc: 0.7812

Epoch 00034: val_acc did not improve from 0.80375
Epoch 35/40
200/200 [==============================] - 214s 1s/step - loss: 0.2989 - acc: 0.8744 - va
l_loss: 0.4880 - val_acc: 0.7762

Epoch 00035: val_acc did not improve from 0.80375
Epoch 36/40
200/200 [==============================] - 215s 1s/step - loss: 0.2918 - acc: 0.8788 - va
l_loss: 0.5054 - val_acc: 0.7700

Epoch 00036: val_acc did not improve from 0.80375
Epoch 37/40
200/200 [==============================] - 217s 1s/step - loss: 0.2868 - acc: 0.8769 - va
l_loss: 0.4933 - val_acc: 0.7837

Epoch 00037: val_acc did not improve from 0.80375
Epoch 38/40
200/200 [==============================] - 216s 1s/step - loss: 0.2940 - acc: 0.8778 - va
l_loss: 0.5112 - val_acc: 0.7819

Epoch 00038: val_acc did not improve from 0.80375
Epoch 39/40
200/200 [==============================] - 216s 1s/step - loss: 0.2731 - acc: 0.8872 - va
l_loss: 0.5372 - val_acc: 0.7700

Epoch 00039: val_acc did not improve from 0.80375
Epoch 40/40
200/200 [==============================] - 215s 1s/step - loss: 0.2996 - acc: 0.8766 - va
l_loss: 0.5230 - val_acc: 0.7688

Epoch 00040: val_acc did not improve from 0.80375
```

In [0]:

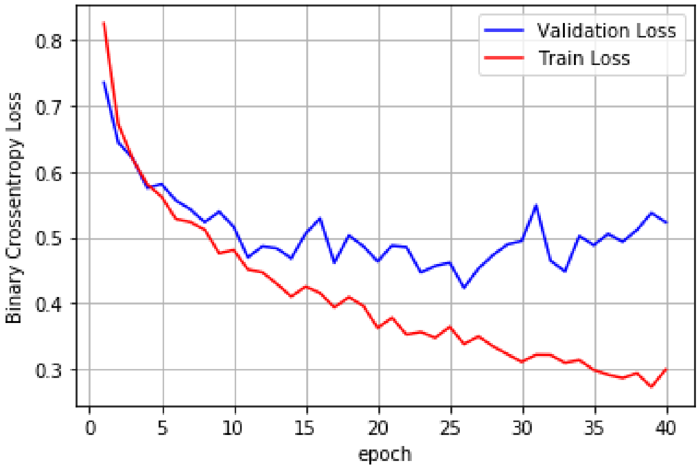
```
model.save("fn_vgg_new_100_epoch.h5")
```

In [0]:

```
def plt_dynamic(x, vy, ty, ax, colors=['b']):
    ax.plot(x, vy, 'b', label="Validation Loss")
    ax.plot(x, ty, 'r', label="Train Loss")
    plt.legend()
    plt.grid()
    fig.canvas.draw()
def plt_dynamic1(x, vy, ty, ax, colors=['b']):
    ax.plot(x, vy, 'b', label="Validation Accuracy")
    ax.plot(x, ty, 'r', label="Training Accuracy")
    plt.legend()
    plt.grid()
    fig.canvas.draw()
```

In [0]:

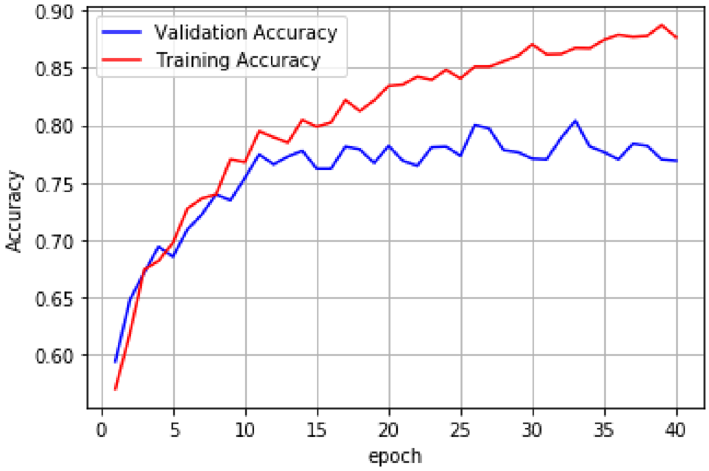
```
fig,ax = plt.subplots(1,1)
ax.set_xlabel('epoch') ; ax.set_ylabel('Binary Crossentropy Loss')
x = list(range(1,41))
vl = inspect.history['val_loss']
tl = inspect.history['loss']
plt_dynamic(x, vl, tl, ax)
```



In [0]:

In [0]:

```
fig,ax = plt.subplots(1,1)
ax.set_xlabel('epoch') ; ax.set_ylabel('Accuracy')
x = list(range(1,41))
vacc = inspect.history['val_acc']
tacc = inspect.history['acc']
plt_dynamic1(x, vacc, tacc, ax)
```



In [0]:

```
from keras.models import load_model
fn_vgg_new_best= load_model('fn_vgg_new.h5')
```

```
Using TensorFlow backend.
```

The default version of TensorFlow in Colab will soon switch to TensorFlow 2.x.
We recommend you upgrade now or ensure your notebook will continue to use TensorFlow 1.x via the `%tensorflow_version 1.x` magic: more info.

```
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorflow_b
ackend.py:541: The name tf.placeholder is deprecated. Please use tf.compat.v1.placeholder
instead.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorflow_b
ackend.py:4432: The name tf.random_uniform is deprecated. Please use tf.random.uniform in
stead.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorflow_b
ackend.py:66: The name tf.get_default_graph is deprecated. Please use tf.compat.v1.get_de
fault_graph instead.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorflow_b
ackend.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/backend/tensorflow_b
ackend.py:197: The name tf.ConfigProto is deprecated. Please use tf.compat.v1.ConfigProto
instead.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorflow_b
ackend.py:203: The name tf.Session is deprecated. Please use tf.compat.v1.Session instead
.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorflow_b
ackend.py:207: The name tf.global_variables is deprecated. Please use tf.compat.v1.global
_variables instead.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorflow_b
ackend.py:216: The name tf.is_variable_initialized is deprecated. Please use tf.compat.v1
.is_variable_initialized instead.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorflow_b
ackend.py:223: The name tf.variables_initializer is deprecated. Please use tf.compat.v1.v
ariables_initializer instead.
```

```
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorflow_b
ackend.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/backend/tensorflow_b
ackend.py:148: The name tf.placeholder_with_default is deprecated. Please use tf.compat.v
1.placeholder_with_default instead.

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

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorflow_b
ackend.py:3733: calling dropout (from tensorflow.python.ops.nn_ops) with keep_prob is dep
recated and will be removed in a future version.
Instructions for updating:
Please use `rate` instead of `keep_prob`. Rate should be set to `rate = 1 - keep_prob`.
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorflow_b
ackend.py:4271: The name tf.nn.avg_pool is deprecated. Please use tf.nn.avg_pool2d instea
d.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/optimizers.py:793: T
he 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/backend/tensorflow_b
ackend.py:3657: The name tf.log is deprecated. Please use tf.math.log instead.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/tensorflow_core/python/ops
/nn_impl.py:183: where (from tensorflow.python.ops.array_ops) is deprecated and will be r
emoved in a future version.
Instructions for updating:
Use tf.where in 2.0, which has the same broadcast rule as np.where
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorflow_b
ackend.py:1033: The name tf.assign_add is deprecated. Please use tf.compat.v1.assign_add
instead.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorflow_b
ackend.py:1020: The name tf.assign is deprecated. Please use tf.compat.v1.assign instead.
```

In [0]:

```
predictions = []
chunksize =100
df = 'sample_submission.csv'
for chunk in tqdm(pd.read_csv(df,chunksize=chunksize)):
    batch = chunk.img_pair.values
    X1 = [x.split("-")[0] for x in batch]
    image_fn_1 = np.array([getimage_fn('test/' + x) for x in X1])
    image_vgg_1 = np.array([getimage_vgg('test/' + x) for x in X1])
    X2 = [x.split("-")[1] for x in batch]
    image_fn_2 = np.array([getimage_fn('test/' + x) for x in X2])
    image_vgg_2 = np.array([getimage_vgg('test/' + x) for x in X2])
    prediction = fn_vgg_new_best.predict([image_vgg_1,image_vgg_2,image_fn_1,image_fn_2]
).ravel().tolist()
    predictions += prediction
```

```
0it [00:00, ?it/s]
1it [01:05, 65.28s/it]
2it [02:32, 71.89s/it]
3it [03:55, 75.17s/it]
4it [05:31, 81.30s/it]
5it [06:46, 79.43s/it]
6it [08:06, 79.74s/it]
7it [09:22, 78.52s/it]
8it [10:34, 76.63s/it]
9it [11:46, 75.29s/it]
10it [12:51, 72.04s/it]
11it [13:58, 70.66s/it]
12it [14:57, 67.03s/it]
13it [16:06, 67.75s/it]
```

```
14it [17:12, 67.34s/it]
15it [18:12, 65.11s/it]
16it [19:11, 63.34s/it]
17it [20:11, 62.23s/it]
18it [21:10, 61.23s/it]
19it [22:06, 59.74s/it]
20it [23:06, 59.70s/it]
21it [23:57, 57.18s/it]
22it [24:51, 56.28s/it]
23it [25:35, 52.46s/it]
24it [26:22, 50.77s/it]
25it [27:20, 53.02s/it]
26it [28:09, 51.84s/it]
27it [28:49, 48.26s/it]
28it [29:40, 49.17s/it]
29it [30:30, 49.47s/it]
30it [31:15, 47.94s/it]
31it [31:58, 46.65s/it]
32it [32:39, 44.73s/it]
33it [33:20, 43.55s/it]
34it [34:05, 44.09s/it]
35it [34:44, 42.57s/it]
36it [35:23, 41.58s/it]
37it [36:07, 42.35s/it]
38it [36:42, 40.00s/it]
39it [37:26, 41.29s/it]
40it [38:03, 39.97s/it]
41it [38:43, 39.89s/it]
42it [39:20, 39.02s/it]
43it [40:02, 40.12s/it]
44it [40:45, 40.94s/it]
45it [41:27, 41.29s/it]
46it [42:08, 41.03s/it]
47it [42:46, 40.31s/it]
48it [43:32, 41.83s/it]
49it [44:07, 39.77s/it]
50it [44:56, 42.66s/it]
51it [45:41, 43.35s/it]
52it [46:25, 43.56s/it]
53it [47:05, 42.40s/it]
54it [47:10, 31.14s/it]
```

In [0]:

```
result = pd.read_csv('sample_submission.csv')
result['is_related'] = predictions
result.to_csv("fn_vgg_new_best.csv", index= False)
```

In [0]:

```
fn_vgg_new_100_epoch = load_model('fn_vgg_new_100_epoch.h5')
```

In [0]:

```
predictions = []
chunksize =100
df = 'sample_submission.csv'
for chunk in tqdm(pd.read_csv(df,chunksize=chunksize)):
    batch = chunk.img_pair.values
    X1 = [x.split("-")[0] for x in batch]
    image_fn_1 = np.array([getimage_fn('test/' + x) for x in X1])
    image_vgg_1 = np.array([getimage_vgg('test/' + x) for x in X1])
    X2 = [x.split("-")[1] for x in batch]
    image_fn_2 = np.array([getimage_fn('test/' + x) for x in X2])
    image_vgg_2 = np.array([getimage_vgg('test/' + x) for x in X2])
    prediction = fn_vgg_new_100_epoch.predict([image_vgg_1,image_vgg_2,image_fn_1,image_
fn_2]).ravel().tolist()
    predictions += prediction
```

```
0it [00:00, ?it/s]
1it [00:20, 20.44s/it]
2it [00:25, 15.71s/it]
```

```
2it [00:25, 15.71s/it]
3it [00:28, 12.02s/it]
4it [00:31,  9.44s/it]
5it [00:35,  7.64s/it]
6it [00:38,  6.41s/it]
7it [00:42,  5.51s/it]
8it [00:45,  4.88s/it]
9it [00:49,  4.43s/it]
10it [00:52,  4.13s/it]
11it [00:56,  3.95s/it]
12it [00:59,  3.79s/it]
13it [01:02,  3.66s/it]
14it [01:06,  3.57s/it]
15it [01:09,  3.55s/it]
16it [01:13,  3.50s/it]
17it [01:16,  3.46s/it]
18it [01:19,  3.42s/it]
19it [01:23,  3.44s/it]
20it [01:26,  3.42s/it]
21it [01:30,  3.45s/it]
22it [01:33,  3.49s/it]
23it [01:37,  3.53s/it]
24it [01:40,  3.48s/it]
25it [01:44,  3.45s/it]
26it [01:47,  3.44s/it]
27it [01:50,  3.43s/it]
28it [01:54,  3.42s/it]
29it [01:57,  3.42s/it]
30it [02:01,  3.43s/it]
31it [02:04,  3.43s/it]
32it [02:08,  3.43s/it]
33it [02:11,  3.40s/it]
34it [02:14,  3.40s/it]
35it [02:18,  3.40s/it]
36it [02:21,  3.38s/it]
37it [02:24,  3.37s/it]
38it [02:28,  3.38s/it]
39it [02:31,  3.38s/it]
40it [02:35,  3.40s/it]
41it [02:38,  3.43s/it]
42it [02:41,  3.41s/it]
43it [02:45,  3.39s/it]
44it [02:48,  3.38s/it]
45it [02:52,  3.39s/it]
46it [02:55,  3.40s/it]
47it [02:58,  3.38s/it]
48it [03:02,  3.38s/it]
49it [03:05,  3.39s/it]
50it [03:09,  3.44s/it]
51it [03:12,  3.42s/it]
52it [03:15,  3.41s/it]
53it [03:19,  3.41s/it]
54it [03:19,  2.51s/it]
```

In [0]:

```
result = pd.read_csv('sample_submission.csv')
result['is_related'] = predictions
result.to_csv("fn_vgg_new_100_epoch.csv", index= False)
```

COMBINED MODELS

1st Combined Model

In [0]:

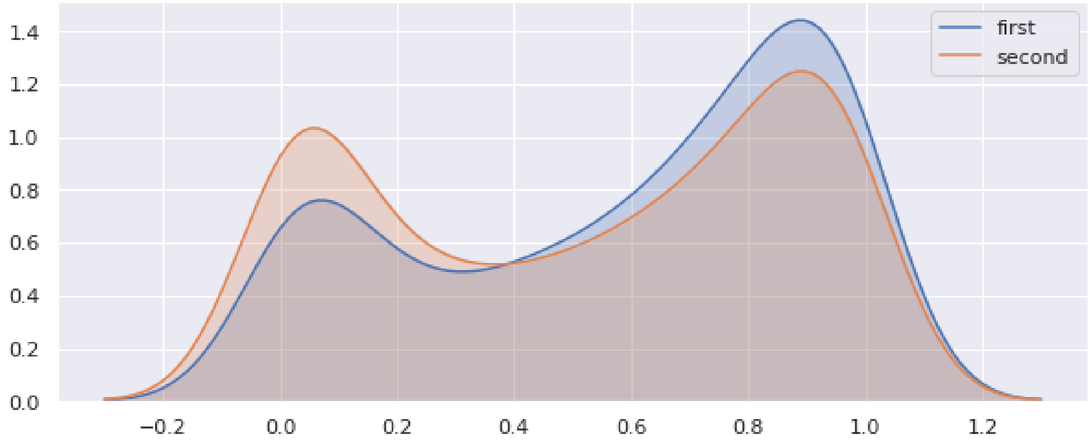
```
first = pd.read_csv('fn_vgg_new_best.csv')
second = pd.read_csv('fn_vgg_new_100_epoch.csv')
```

In [0]:

```
sns.set(rc={'figure.figsize':(10,4)})
sns.kdeplot(first['is_related'],label="first",shade= True,bw=.1)
sns.kdeplot(second['is_related'], label="second",shade= True,bw=.1)
```

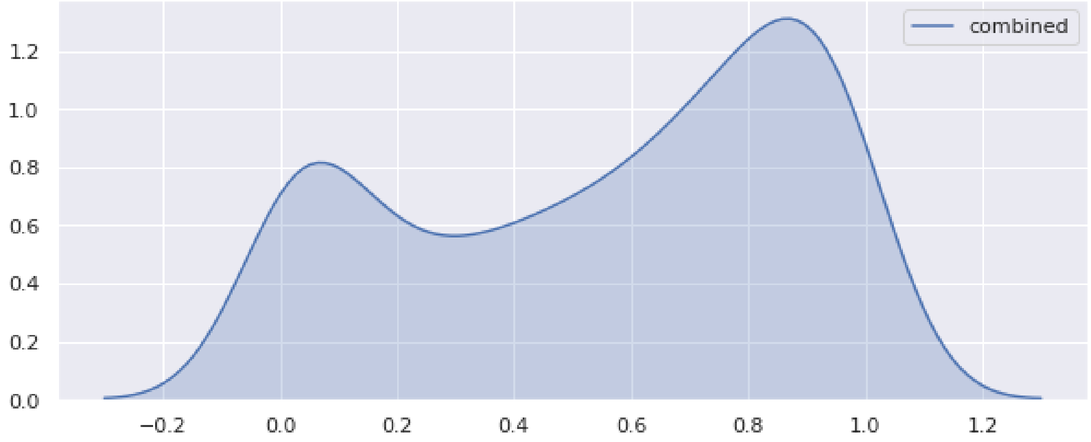
Out[0]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x7fc69fa2ce10>
```



In [0]:

```
result = pd.read_csv('sample_submission.csv')
result['is_related'] = 0.50*first['is_related'] + 0.50*second['is_related']
sns.kdeplot(result['is_related'],label="combined",shade= True,bw=.1)
plt.show()
```



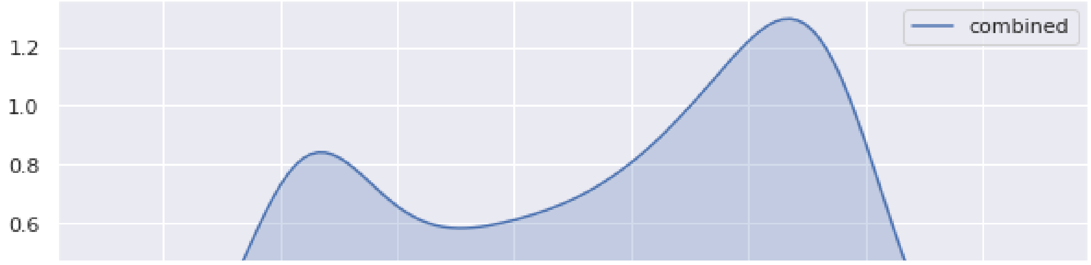
2nd Combined Model

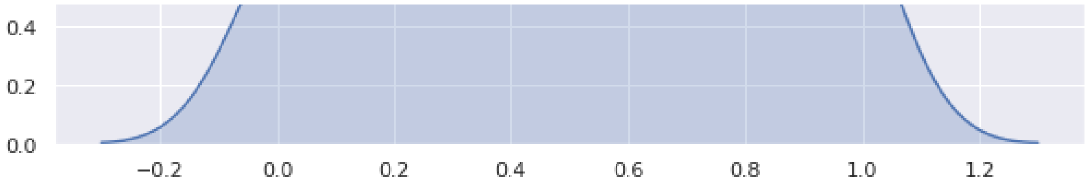
In [0]:

```
result.to_csv('fn_vgg_new_combined_1.csv', index= False)
```

In [0]:

```
result = pd.read_csv('sample_submission.csv')
result['is_related'] = 0.40*first['is_related'] + 0.60*second['is_related']
sns.kdeplot(result['is_related'],label="combined",shade= True,bw=.1)
plt.show()
```





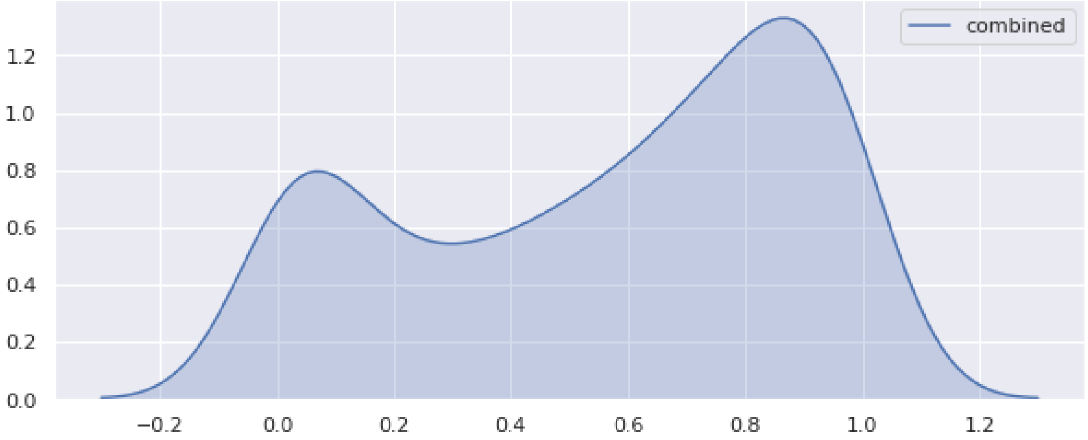
In [0]:

```
result.to_csv('fn_vgg_new_combined_2.csv', index= False)
```

3rd Combined Model

In [0]:

```
result = pd.read_csv('sample_submission.csv')
result['is_related'] = 0.60*first['is_related'] + 0.40*second['is_related']
sns.kdeplot(result['is_related'],label="combined",shade= True,bw=.1)
plt.show()
```



In [0]:

```
result.to_csv('fn_vgg_new_combined_3.csv', index= False)
```

EVALUATING MODEL 1(BEST WEIGHTS)

KAGGLE SCORES-> 0.865 (Public), 0.868 (Private)

In [0]:

```
from keras.models import load_model
fn_vgg_new_best= load_model('fn_vgg_new.h5')
```

In [0]:

```
from keras.optimizers import Adam
from keras.losses import binary_crossentropy
from sklearn.metrics import roc_auc_score
import tensorflow as tf
#auroc metric
def aucc(y_true, y_pred):
   if len(np.unique(y_true)) == 1:
      return 0.5
   else:
      return roc_auc_score(y_true, y_pred)
def auroc(y_true, y_pred):
    return tf.py_func(aucc, (y_true, y_pred), tf.double)
```

In [31]:

```
fn_vgg_new_best.compile(loss="binary_crossentropy",optimizer=Adam(0.00001),metrics=['acc
fn_vgg_new_best.compile(loss="binary_crossentropy",optimizer=Adam(0.00001),metrics=['acc
uracy',auroc])
```

```
WARNING:tensorflow:From <ipython-input-28-50e4381d563b>:12: py_func (from tensorflow.pyth
on.ops.script_ops) is deprecated and will be removed in a future version.
Instructions for updating:
tf.py_func is deprecated in TF V2. Instead, there are two
    options available in V2.
    - tf.py_function takes a python function which manipulates tf eager
    tensors instead of numpy arrays. It's easy to convert a tf eager tensor to
    an ndarray (just call tensor.numpy()) but having access to eager tensors
    means `tf.py_function`s can use accelerators such as GPUs as well as
    being differentiable using a gradient tape.
    - tf.numpy_function maintains the semantics of the deprecated tf.py_func
    (it is not differentiable, and manipulates numpy arrays). It drops the
    stateful argument making all functions stateful.
```

In [33]:

```
# This evaluating generator returns metrics such as Loss(Binary cross entropy),Accuracy ,
AUROC Score in order
#Evaluating on Train Data
fn_vgg_new_best.evaluate_generator(generator(train_pairs, image_dict_train, batch_size=16
), steps = 200)
```

Out[33]:

```
[0.3187491707876325, 0.8671875, 0.95484375]
```

In [35]:

```
# This evaluating generator returns metrics such as Loss(Binary cross entropy),Accuracy ,
AUROC Score in order
#Evaluating on Validation Data
fn_vgg_new_best.evaluate_generator(generator(val_pairs, image_dict_val, batch_size=16), s
teps = 100)
```

Out[35]:

```
[0.45022138968110087, 0.798125, 0.870625]
```

EVALUATING MODEL 2(WEIGHTS AFTER 40 EPOCHS)

KAGGLE SCORES-> 0.874 (Public) , 0.877 (Private)

In [0]:

```
fn_vgg_new_40_epoch = load_model('fn_vgg_new_100_epoch.h5')
```

In [0]:

```
fn_vgg_new_40_epoch.compile(loss="binary_crossentropy",optimizer=Adam(0.00001),metrics=[
'accuracy',auroc])
```

In [43]:

```
# This evaluating generator returns metrics such as Loss(Binary cross entropy),Accuracy ,
AUROC Score in order
#Evaluating on Train Data
fn_vgg_new_40_epoch.evaluate_generator(generator(train_pairs, image_dict_train, batch_siz
e=16), steps = 200)
```

Out[43]:

```
[0.2613425075262785, 0.8953125, 0.9646875]
```

In [41]:

```
# This evaluating generator returns metrics such as Loss(Binary cross entropy),Accuracy ,
AUROC Score in order
#Evaluating on Validation Data
fn_vgg_new_40_epoch.evaluate_generator(generator(val_pairs, image_dict_val, batch_size=16
), steps = 100)
```

Out[41]:

```
[0.4811488364636898, 0.780625, 0.8709375]
```

EVALUATING COMBINED MODEL 1

KAGGLE SCORES -> 0.880 (Public) , 0.881 (Private)

In [78]:

```
predictions = []
lables = []
for i in tqdm(range(0,100)):
  samples , l = next(generator(val_pairs, image_dict_val, batch_size=16))
  pred = 0.50*fn_vgg_new_best.predict(samples) + 0.50*fn_vgg_new_40_epoch.predict(sample
s)
  predictions += pred.ravel().tolist()
  lables += l
AUROC = auroc(lables,predictions)
with tf.Session() as sess:
    init = tf.global_variables_initializer()
    sess.run(init)
    print('The AUROC is ',AUROC.eval())
```

```
100%|██████████| 100/100 [01:07<00:00,  1.49it/s]
```

```
The AUROC is  0.8825468750000001
```

EVALUATING COMBINED MODEL 2

KAGGLE SCORES-> 0.880 (Public) , 0.881 (Private)

In [79]:

```
predictions = []
lables = []
for i in tqdm(range(0,100)):
  samples , l = next(generator(val_pairs, image_dict_val, batch_size=16))
  pred = 0.40*fn_vgg_new_best.predict(samples) + 0.60*fn_vgg_new_40_epoch.predict(sample
s)
  predictions += pred.ravel().tolist()
  lables += l
AUROC = auroc(lables,predictions)
with tf.Session() as sess:
    init = tf.global_variables_initializer()
    sess.run(init)
    print('The AUROC is ',AUROC.eval())
```

```
100%|██████████| 100/100 [01:07<00:00,  1.49it/s]
```

```
The AUROC is  0.8867046875
```

EVALUATING COMBINED MODEL 3

KAGGLE SCORES-> 0.879 (Public) , 0.880 (Private)

In [80]:

```
predictions = []
```

```
lables = []
for i in tqdm(range(0,100)):
  samples , l = next(generator(val_pairs, image_dict_val, batch_size=16))
  pred = 0.60*fn_vgg_new_best.predict(samples) + 0.40*fn_vgg_new_40_epoch.predict(sample
s)
  predictions += pred.ravel().tolist()
  lables += l
AUROC = auroc(lables,predictions)
with tf.Session() as sess:
    init = tf.global_variables_initializer()
    sess.run(init)
    print('The AUROC is ',AUROC.eval())
```

```
100%|██████████| 100/100 [01:05<00:00,  1.48it/s]
```

```
The AUROC is  0.8763453124999999
```