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?cli
ent_id=947318989803-6bn6qk8qdgf4n4g3pfee6491hc0brc4i.apps.googleuserconten
t.com&redirect_uri=urn%3Aietf%3Awg%3Aoauth%3A2.0%3Aoob&scope=email%20http
s%3A%2F%2Fwww.googleapis.com%2Fauth%2Fdocs.test%20https%3A%2F%2Fwww.google
apis.com%2Fauth%2Fdrive%20https%3A%2F%2Fwww.googleapis.com%2Fauth%2Fdrive.
photos.readonly%20https%3A%2F%2Fwww.googleapis.com%2Fauth%2Fpeopleapi.read
only&response_type=code

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

In [2]:

```
!pip install git+https://github.com/rcmalli/keras-vggface.git
```

```
Collecting git+https://github.com/rcmalli/keras-vggface.git
  Cloning https://github.com/rcmalli/keras-vggface.git to /tmp/pip-req-bui
ld-9spayvfa
  Running command git clone -q https://github.com/rcmalli/keras-vggface.gi
t /tmp/pip-req-build-9spayvfa
Requirement already satisfied: numpy>=1.9.1 in /usr/local/lib/python3.6/di
st-packages (from keras-vggface==0.6) (1.16.4)
Requirement already satisfied: scipy>=0.14 in /usr/local/lib/python3.6/dis
t-packages (from keras-vggface==0.6) (1.3.1)
Requirement already satisfied: h5py in /usr/local/lib/python3.6/dist-packa
ges (from keras-vggface==0.6) (2.8.0)
Requirement already satisfied: pillow in /usr/local/lib/python3.6/dist-pac
kages (from keras-vggface==0.6) (4.3.0)
Requirement already satisfied: keras in /usr/local/lib/python3.6/dist-pack
ages (from keras-vggface==0.6) (2.2.4)
Requirement already satisfied: six>=1.9.0 in /usr/local/lib/python3.6/dist
-packages (from keras-vggface==0.6) (1.12.0)
Requirement already satisfied: pyyaml in /usr/local/lib/python3.6/dist-pac
kages (from keras-vggface==0.6) (3.13)
Requirement already satisfied: olefile in /usr/local/lib/python3.6/dist-pa
ckages (from pillow->keras-vggface==0.6) (0.46)
Requirement already satisfied: keras-applications>=1.0.6 in /usr/local/li
b/python3.6/dist-packages (from keras->keras-vggface==0.6) (1.0.8)
Requirement already satisfied: keras-preprocessing>=1.0.5 in /usr/local/li
b/python3.6/dist-packages (from keras->keras-vggface==0.6) (1.1.0)
Building wheels for collected packages: keras-vggface
  Building wheel for keras-vggface (setup.py) ... done
  Created wheel for keras-vggface: filename=keras_vggface-0.6-cp36-none-an
y.whl size=8311 sha256=153702d8b32665440849dfff0c243120664fa9f127753787a8f
1236190db5e6b
  Stored in directory: /tmp/pip-ephem-wheel-cache-fup5o0ta/wheels/36/07/4
6/06c25ce8e9cd396dabe151ea1d8a2bc28dafcb11321c1f3a6d
Successfully built keras-vggface
Installing collected packages: keras-vggface
Successfully installed keras-vggface-0.6
```

In [0]:

```
import warnings
warnings.filterwarnings('ignore')
```

In [0]:

```
import h5py
from collections import defaultdict
from glob import glob
from random import choice,sample
import cv2
import numpy as np
import pandas as pd
from tqdm import tqdm
```

In [5]:

```
from keras.callbacks import ModelCheckpoint,ReduceLROnPlateau
from keras.layers import Input,Dense,GlobalMaxPool2D,GlobalAvgPool2D,Concatenate,Multip
ly,Dropout,Subtract,Lambda
from keras.models import Model
from keras.optimizers import Adam
from keras_vggface.utils import preprocess_input
from keras_vggface.vggface import VGGFace
from keras import backend as K
from keras.models import load_model
```

```
Using TensorFlow backend.
```

In [0]:

```
train_file_path='/content/drive/My Drive/Recognizing_Faces_in_the_Wild/train_relationsh
ips.csv'
train_folders_path='/content/drive/My Drive/Recognizing_Faces_in_the_Wild/train/'
val_families='F09' #families which has F09*** in folder name
```

In [7]:

```
%%time
all_images=glob(train_folders_path+'*/*/*.jpg') #paths of all images
train_images=[x for x in all_images if val_families not in x] #path of images used for
 training
val_images=[x for x in all_images if val_families in x] #path of validation images (bel
onging to families starting with F09***)
```

```
CPU times: user 368 ms, sys: 263 ms, total: 631 ms
Wall time: 2min 54s
```

In [0]:

```
ppl=[x.split('/')[-3]+'/'+x.split("/")[-2] for x in all_images] #obtaining the people i
n the format give in train_relationship
```

In [0]:

```
#Mapping people to their faces (list of faces)
train_person_to_images_map=defaultdict(list)
for x in train_images:
  train_person_to_images_map[x.split('/')[-3]+'/'+x.split("/")[-2]].append(x)

val_person_to_images_map=defaultdict(list)
for x in val_images:
  val_person_to_images_map[x.split('/')[-3]+'/'+x.split('/')[-2]].append(x)
```

In [0]:

```
#Obtaining relationship pairs and converting them to tuples
relationships = pd.read_csv(train_file_path)
relationships = list(zip(relationships.p1.values, relationships.p2.values))
relationships = [x for x in relationships if x[0] in ppl and x[1] in ppl]
```

In [0]:

```
#Diving the tuples into train and validation
train=[x for x in relationships if val_families not in x[0]]
val=[x for x in relationships if val_families in x[0]]
```

In [0]:

```
#reads the image and converts into numpy aarray and finally returns the image processed
as required by VGGFace
def img2arr(path):
  img=cv2.imread(path)
  img=np.array(img).astype(np.float)
  return preprocess_input(img,version=2)
```

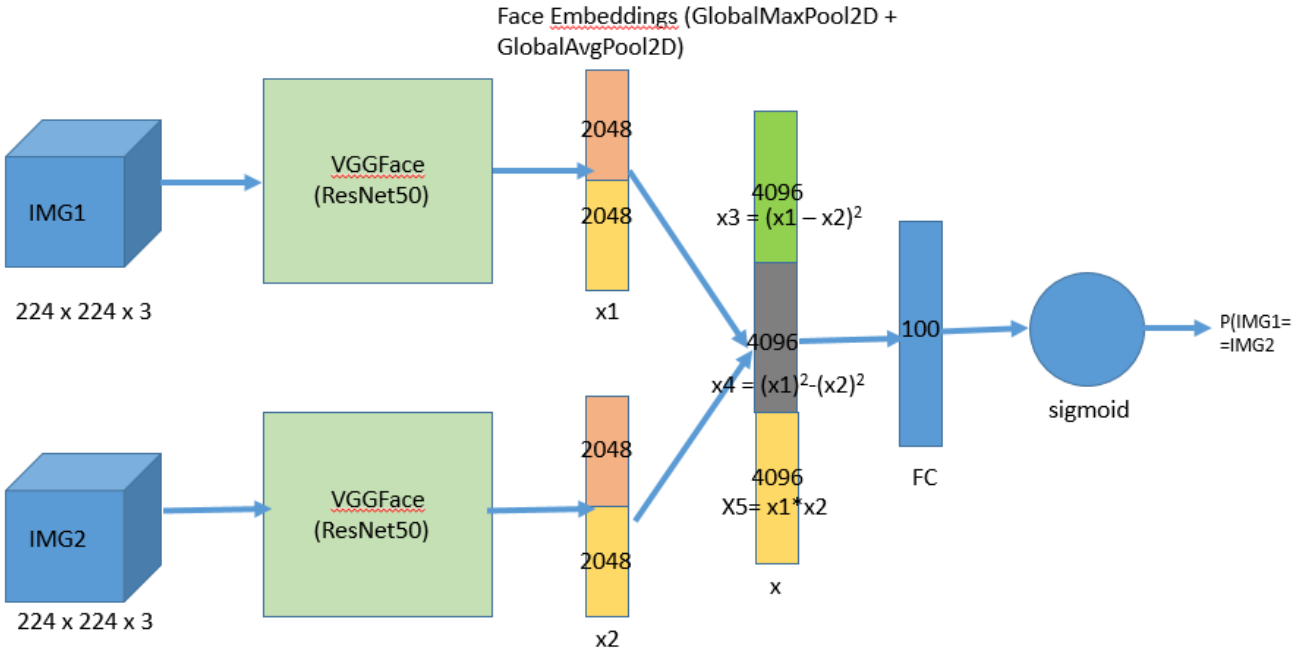
In [0]:

```
#Generator to use with fit_generator to generate data in batches
def data_generator(list_tuples,person_to_images_map,batch_size=16):
  ppl=list(person_to_images_map.keys())
  while True:
    batch_tuples=sample(list_tuples,batch_size//2)
    labels=[1]*len(batch_tuples)
    while len(batch_tuples)<batch_size:
      p1=choice(ppl)
      p2=choice(ppl)

      if p1!=p2 and (p1,p2) not in list_tuples and (p2,p1) not in list_tuples:
        batch_tuples.append((p1,p2))
        labels.append(0)
    for x in batch_tuples:
      if not len(person_to_images_map[x[0]]):
        print(x[0])
    X1=[choice(person_to_images_map[x[0]]) for x in batch_tuples]
    X1=np.array([img2arr(x) for x in X1])
    X2=[choice(person_to_images_map[x[1]]) for x in batch_tuples]
    X2=np.array([img2arr(x) for x in X2])

    yield [X1,X2],labels
```

Model Architecture



In [0]:

```
#Model architecture
def build_model():
  input1=Input(shape=(224,224,3))
  input2=Input(shape=(224,224,3))

  base_model=VGGFace(model='resnet50',include_top=False)

  '''for x in base_model.layers[:-3]:
    x.trainable=True'''

  x1=base_model(input1)
  x2=base_model(input2)

  x1=Concatenate(axis=-1)([GlobalMaxPool2D()(x1),GlobalAvgPool2D()(x1)])
  x2=Concatenate(axis=-1)([GlobalMaxPool2D()(x2),GlobalAvgPool2D()(x2)])

  x3=Subtract()([x1,x2])
  x3=Multiply()([x3,x3])
  #x=Multiply()([x3,x3])

  #x=Multiply()([x1,x2])
  x1_=Multiply()([x1,x1])
  x2_=Multiply()([x2,x2])
  x4=Subtract()([x1_,x2_])

  x5=Multiply()([x1,x2])

  x=Concatenate(axis=-1)([x3,x4,x5])

  x=Dense(100,activation='relu')(x)
  x=Dropout(0.01)(x)
  out=Dense(1,activation='sigmoid')(x)

  model=Model([input1,input2],out)

  model.compile(loss='binary_crossentropy',metrics=['acc'],optimizer=Adam(0.00001))

  model.summary()

  return model
```

In [0]:

```
file_path='/content/drive/My Drive/Recognizing_Faces_in_the_Wild/20190824/vgg_face.h5'
```

In [0]:

```
#Using callbacks
checkpoint=ModelCheckpoint(file_path,monitor='val_acc',verbose=1,save_best_only=True,mo
de='max') #Saves the best model based on val_acc

reduce_lr_on_plateau=ReduceLROnPlateau(monitor='val_acc',mode='max',factor=0.1,patience
=20,verbose=1) #Reduces the learning rate when val_acc is not improving

callbacks_list=[checkpoint,reduce_lr_on_plateau]
```

In [18]:

```
model=build_model()

history=model.fit_generator(data_generator(train,train_person_to_images_map,batch_size=
16),\
                    use_multiprocessing=True,\
                    validation_data=data_generator(val, val_person_to_images_map, batch
_size=16),\
                    epochs=100,verbose=1,workers=4,callbacks=callbacks_list,steps_per_e
poch=200,validation_steps=100)
```

```
WARNING: Logging before flag parsing goes to stderr.
W0824 16:28:16.535361 140109749909376 deprecation_wrapper.py:119] From /us
r/local/lib/python3.6/dist-packages/keras/backend/tensorflow_backend.py:7
4: The name tf.get_default_graph is deprecated. Please use tf.compat.v1.ge
t_default_graph instead.

W0824 16:28:16.583397 140109749909376 deprecation_wrapper.py:119] From /us
r/local/lib/python3.6/dist-packages/keras/backend/tensorflow_backend.py:51
7: The name tf.placeholder is deprecated. Please use tf.compat.v1.placehol
der instead.

W0824 16:28:16.593642 140109749909376 deprecation_wrapper.py:119] From /us
r/local/lib/python3.6/dist-packages/keras/backend/tensorflow_backend.py:41
38: The name tf.random_uniform is deprecated. Please use tf.random.uniform
instead.

W0824 16:28:16.634713 140109749909376 deprecation_wrapper.py:119] From /us
r/local/lib/python3.6/dist-packages/keras/backend/tensorflow_backend.py:17
4: The name tf.get_default_session is deprecated. Please use tf.compat.v1.
get_default_session instead.

W0824 16:28:16.636055 140109749909376 deprecation_wrapper.py:119] From /us
r/local/lib/python3.6/dist-packages/keras/backend/tensorflow_backend.py:18
1: The name tf.ConfigProto is deprecated. Please use tf.compat.v1.ConfigPr
oto instead.

W0824 16:28:19.507476 140109749909376 deprecation_wrapper.py:119] From /us
r/local/lib/python3.6/dist-packages/keras/backend/tensorflow_backend.py:18
34: The name tf.nn.fused_batch_norm is deprecated. Please use tf.compat.v
1.nn.fused_batch_norm instead.

W0824 16:28:19.680394 140109749909376 deprecation_wrapper.py:119] From /us
r/local/lib/python3.6/dist-packages/keras/backend/tensorflow_backend.py:39
76: The name tf.nn.max_pool is deprecated. Please use tf.nn.max_pool2d ins
tead.

W0824 16:28:24.887172 140109749909376 deprecation_wrapper.py:119] From /us
r/local/lib/python3.6/dist-packages/keras/backend/tensorflow_backend.py:39
80: The name tf.nn.avg_pool is deprecated. Please use tf.nn.avg_pool2d ins
tead.


Downloading data from https://github.com/rcmalli/keras-vggface/releases/do
wnload/v2.0/rcmalli_vggface_tf_notop_resnet50.h5
94699520/94694792 [==============================] - 1s 0us/step
```

```
W0824 16:28:37.291864 140109749909376 deprecation.py:506] From /usr/local/
lib/python3.6/dist-packages/keras/backend/tensorflow_backend.py:3445: call
ing dropout (from tensorflow.python.ops.nn_ops) with keep_prob is deprecat
ed 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`.
W0824 16:28:37.336609 140109749909376 deprecation_wrapper.py:119] From /us
r/local/lib/python3.6/dist-packages/keras/optimizers.py:790: The name tf.t
rain.Optimizer is deprecated. Please use tf.compat.v1.train.Optimizer inst
ead.

W0824 16:28:37.348724 140109749909376 deprecation.py:323] From /usr/local/
lib/python3.6/dist-packages/tensorflow/python/ops/nn_impl.py:180: add_disp
atch_support.<locals>.wrapper (from tensorflow.python.ops.array_ops) is de
precated 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
```

```
__________________________________________________________________________
_____________________
Layer (type)                 Output Shape              Param #     Connected
to
==========================================================================
=======================
input_1 (InputLayer)         (None, 224, 224, 3)       0
__________________________________________________________________________
_____________________
input_2 (InputLayer)         (None, 224, 224, 3)       0
__________________________________________________________________________
_____________________
vggface_resnet50 (Model)     multiple                  23561152    input_1
[0][0]
                                                                   input_2
[0][0]
__________________________________________________________________________
_____________________
global_max_pooling2d_1 (GlobalM (None, 2048)           0           vggface_r
esnet50[1][0]
__________________________________________________________________________
_____________________
global_average_pooling2d_1 (Glo (None, 2048)           0           vggface_r
esnet50[1][0]
__________________________________________________________________________
_____________________
global_max_pooling2d_2 (GlobalM (None, 2048)           0           vggface_r
esnet50[2][0]
__________________________________________________________________________
_____________________
global_average_pooling2d_2 (Glo (None, 2048)           0           vggface_r
esnet50[2][0]
__________________________________________________________________________
_____________________
concatenate_1 (Concatenate)  (None, 4096)              0           global_ma
x_pooling2d_1[0][0]
                                                                   global_av
erage_pooling2d_1[0][0]
__________________________________________________________________________
_____________________
concatenate_2 (Concatenate)  (None, 4096)              0           global_ma
x_pooling2d_2[0][0]
                                                                   global_av
erage_pooling2d_2[0][0]
__________________________________________________________________________
_____________________
subtract_1 (Subtract)        (None, 4096)              0           concatena
te_1[0][0]
                                                                   concatena
te_2[0][0]
__________________________________________________________________________
_____________________
multiply_2 (Multiply)        (None, 4096)              0           concatena
te_1[0][0]
                                                                   concatena
te_1[0][0]
__________________________________________________________________________
_____________________
multiply_3 (Multiply)        (None, 4096)              0           concatena
te_2[0][0]
                                                                   concatena
```

```
te_2[0][0]
__________________________________________________________________________
_____________________
multiply_1 (Multiply)           (None, 4096)         0           subtract_
1[0][0]
                                                                 subtract_
1[0][0]
__________________________________________________________________________
_____________________
subtract_2 (Subtract)           (None, 4096)         0           multiply_
2[0][0]
                                                                 multiply_
3[0][0]
__________________________________________________________________________
_____________________
concatenate_3 (Concatenate)     (None, 8192)         0           multiply_
1[0][0]
                                                                 subtract_
2[0][0]
__________________________________________________________________________
_____________________
dense_1 (Dense)                 (None, 100)          819300      concatena
te_3[0][0]
__________________________________________________________________________
_____________________
dropout_1 (Dropout)             (None, 100)          0           dense_1
[0][0]
__________________________________________________________________________
_____________________
dense_2 (Dense)                 (None, 1)            101         dropout_1
[0][0]
==========================================================================
========================
Total params: 24,380,553
Trainable params: 24,327,433
Non-trainable params: 53,120
__________________________________________________________________________
_____________________
Epoch 1/100
200/200 [==============================] - 408s 2s/step - loss: 4.5966 - a
cc: 0.5784 - val_loss: 4.6615 - val_acc: 0.6062

Epoch 00001: val_acc improved from -inf to 0.60625, saving model to /conte
nt/drive/My Drive/Recognizing_Faces_in_the_Wild/20190824/vgg_face.h5
Epoch 2/100
200/200 [==============================] - 222s 1s/step - loss: 3.7302 - a
cc: 0.6100 - val_loss: 4.3003 - val_acc: 0.5900

Epoch 00002: val_acc did not improve from 0.60625
Epoch 3/100
200/200 [==============================] - 216s 1s/step - loss: 2.5468 - a
cc: 0.6428 - val_loss: 2.9927 - val_acc: 0.5969

Epoch 00003: val_acc did not improve from 0.60625
Epoch 4/100
200/200 [==============================] - 217s 1s/step - loss: 1.3980 - a
cc: 0.6447 - val_loss: 1.6171 - val_acc: 0.6075

Epoch 00004: val_acc improved from 0.60625 to 0.60750, saving model to /co
ntent/drive/My Drive/Recognizing_Faces_in_the_Wild/20190824/vgg_face.h5
Epoch 5/100
```

```
200/200 [==============================] - 217s 1s/step - loss: 0.8909 - a
cc: 0.6466 - val_loss: 1.0744 - val_acc: 0.6012

Epoch 00005: val_acc did not improve from 0.60750
Epoch 6/100
200/200 [==============================] - 217s 1s/step - loss: 0.6753 - a
cc: 0.6856 - val_loss: 0.8883 - val_acc: 0.6369

Epoch 00006: val_acc improved from 0.60750 to 0.63687, saving model to /co
ntent/drive/My Drive/Recognizing_Faces_in_the_Wild/20190824/vgg_face.h5
Epoch 7/100
200/200 [==============================] - 217s 1s/step - loss: 0.6183 - a
cc: 0.6934 - val_loss: 0.7925 - val_acc: 0.6394

Epoch 00007: val_acc improved from 0.63687 to 0.63938, saving model to /co
ntent/drive/My Drive/Recognizing_Faces_in_the_Wild/20190824/vgg_face.h5
Epoch 8/100
200/200 [==============================] - 217s 1s/step - loss: 0.5872 - a
cc: 0.7028 - val_loss: 0.6485 - val_acc: 0.6700

Epoch 00008: val_acc improved from 0.63938 to 0.67000, saving model to /co
ntent/drive/My Drive/Recognizing_Faces_in_the_Wild/20190824/vgg_face.h5
Epoch 9/100
200/200 [==============================] - 217s 1s/step - loss: 0.5466 - a
cc: 0.7250 - val_loss: 0.6808 - val_acc: 0.6631

Epoch 00009: val_acc did not improve from 0.67000
Epoch 10/100
200/200 [==============================] - 217s 1s/step - loss: 0.5409 - a
cc: 0.7188 - val_loss: 0.6705 - val_acc: 0.6756

Epoch 00010: val_acc improved from 0.67000 to 0.67563, saving model to /co
ntent/drive/My Drive/Recognizing_Faces_in_the_Wild/20190824/vgg_face.h5
Epoch 11/100
200/200 [==============================] - 221s 1s/step - loss: 0.5123 - a
cc: 0.7522 - val_loss: 0.6250 - val_acc: 0.6844

Epoch 00011: val_acc improved from 0.67563 to 0.68437, saving model to /co
ntent/drive/My Drive/Recognizing_Faces_in_the_Wild/20190824/vgg_face.h5
Epoch 12/100
200/200 [==============================] - 217s 1s/step - loss: 0.5045 - a
cc: 0.7481 - val_loss: 0.5887 - val_acc: 0.7094

Epoch 00012: val_acc improved from 0.68437 to 0.70937, saving model to /co
ntent/drive/My Drive/Recognizing_Faces_in_the_Wild/20190824/vgg_face.h5
Epoch 13/100
200/200 [==============================] - 217s 1s/step - loss: 0.4758 - a
cc: 0.7653 - val_loss: 0.6255 - val_acc: 0.7113

Epoch 00013: val_acc improved from 0.70937 to 0.71125, saving model to /co
ntent/drive/My Drive/Recognizing_Faces_in_the_Wild/20190824/vgg_face.h5
Epoch 14/100
200/200 [==============================] - 217s 1s/step - loss: 0.4876 - a
cc: 0.7609 - val_loss: 0.6244 - val_acc: 0.7013

Epoch 00014: val_acc did not improve from 0.71125
Epoch 15/100
200/200 [==============================] - 217s 1s/step - loss: 0.4698 - a
cc: 0.7750 - val_loss: 0.5819 - val_acc: 0.7044

Epoch 00015: val_acc did not improve from 0.71125
```

```
Epoch 16/100
200/200 [==============================] - 217s 1s/step - loss: 0.4597 - a
cc: 0.7694 - val_loss: 0.5655 - val_acc: 0.7181

Epoch 00016: val_acc improved from 0.71125 to 0.71813, saving model to /co
ntent/drive/My Drive/Recognizing_Faces_in_the_Wild/20190824/vgg_face.h5
Epoch 17/100
200/200 [==============================] - 217s 1s/step - loss: 0.4473 - a
cc: 0.7937 - val_loss: 0.6061 - val_acc: 0.6994

Epoch 00017: val_acc did not improve from 0.71813
Epoch 18/100
200/200 [==============================] - 216s 1s/step - loss: 0.4580 - a
cc: 0.7766 - val_loss: 0.5775 - val_acc: 0.7231

Epoch 00018: val_acc improved from 0.71813 to 0.72313, saving model to /co
ntent/drive/My Drive/Recognizing_Faces_in_the_Wild/20190824/vgg_face.h5
Epoch 19/100
200/200 [==============================] - 217s 1s/step - loss: 0.4487 - a
cc: 0.7887 - val_loss: 0.5711 - val_acc: 0.7156

Epoch 00019: val_acc did not improve from 0.72313
Epoch 20/100
200/200 [==============================] - 217s 1s/step - loss: 0.4194 - a
cc: 0.8084 - val_loss: 0.5469 - val_acc: 0.7231

Epoch 00020: val_acc did not improve from 0.72313
Epoch 21/100
200/200 [==============================] - 217s 1s/step - loss: 0.4380 - a
cc: 0.7947 - val_loss: 0.5562 - val_acc: 0.7356

Epoch 00021: val_acc improved from 0.72313 to 0.73562, saving model to /co
ntent/drive/My Drive/Recognizing_Faces_in_the_Wild/20190824/vgg_face.h5
Epoch 22/100
200/200 [==============================] - 217s 1s/step - loss: 0.4135 - a
cc: 0.8034 - val_loss: 0.6094 - val_acc: 0.7163

Epoch 00022: val_acc did not improve from 0.73562
Epoch 23/100
200/200 [==============================] - 217s 1s/step - loss: 0.4111 - a
cc: 0.8072 - val_loss: 0.6013 - val_acc: 0.7338

Epoch 00023: val_acc did not improve from 0.73562
Epoch 24/100
200/200 [==============================] - 217s 1s/step - loss: 0.4193 - a
cc: 0.8050 - val_loss: 0.5393 - val_acc: 0.7406

Epoch 00024: val_acc improved from 0.73562 to 0.74062, saving model to /co
ntent/drive/My Drive/Recognizing_Faces_in_the_Wild/20190824/vgg_face.h5
Epoch 25/100
200/200 [==============================] - 217s 1s/step - loss: 0.3886 - a
cc: 0.8247 - val_loss: 0.5326 - val_acc: 0.7550

Epoch 00025: val_acc improved from 0.74062 to 0.75500, saving model to /co
ntent/drive/My Drive/Recognizing_Faces_in_the_Wild/20190824/vgg_face.h5
Epoch 26/100
200/200 [==============================] - 217s 1s/step - loss: 0.3901 - a
cc: 0.8262 - val_loss: 0.5311 - val_acc: 0.7488

Epoch 00026: val_acc did not improve from 0.75500
Epoch 27/100
```

```
200/200 [==============================] - 217s 1s/step - loss: 0.3995 - a
cc: 0.8137 - val_loss: 0.5625 - val_acc: 0.7244

Epoch 00027: val_acc did not improve from 0.75500
Epoch 28/100
200/200 [==============================] - 216s 1s/step - loss: 0.3856 - a
cc: 0.8228 - val_loss: 0.5412 - val_acc: 0.7488

Epoch 00028: val_acc did not improve from 0.75500
Epoch 29/100
200/200 [==============================] - 216s 1s/step - loss: 0.4082 - a
cc: 0.8131 - val_loss: 0.5332 - val_acc: 0.7525

Epoch 00029: val_acc did not improve from 0.75500
Epoch 30/100
200/200 [==============================] - 216s 1s/step - loss: 0.3997 - a
cc: 0.8166 - val_loss: 0.5402 - val_acc: 0.7456

Epoch 00030: val_acc did not improve from 0.75500
Epoch 31/100
200/200 [==============================] - 217s 1s/step - loss: 0.3807 - a
cc: 0.8269 - val_loss: 0.5283 - val_acc: 0.7538

Epoch 00031: val_acc did not improve from 0.75500
Epoch 32/100
200/200 [==============================] - 217s 1s/step - loss: 0.3582 - a
cc: 0.8409 - val_loss: 0.5608 - val_acc: 0.7556

Epoch 00032: val_acc improved from 0.75500 to 0.75562, saving model to /co
ntent/drive/My Drive/Recognizing_Faces_in_the_Wild/20190824/vgg_face.h5
Epoch 33/100
200/200 [==============================] - 217s 1s/step - loss: 0.3672 - a
cc: 0.8344 - val_loss: 0.5541 - val_acc: 0.7344

Epoch 00033: val_acc did not improve from 0.75562
Epoch 34/100
200/200 [==============================] - 217s 1s/step - loss: 0.3618 - a
cc: 0.8359 - val_loss: 0.5389 - val_acc: 0.7431

Epoch 00034: val_acc did not improve from 0.75562
Epoch 35/100
200/200 [==============================] - 217s 1s/step - loss: 0.3714 - a
cc: 0.8350 - val_loss: 0.5081 - val_acc: 0.7481

Epoch 00035: val_acc did not improve from 0.75562
Epoch 36/100
200/200 [==============================] - 216s 1s/step - loss: 0.3617 - a
cc: 0.8363 - val_loss: 0.5346 - val_acc: 0.7394

Epoch 00036: val_acc did not improve from 0.75562
Epoch 37/100
200/200 [==============================] - 216s 1s/step - loss: 0.3537 - a
cc: 0.8466 - val_loss: 0.5530 - val_acc: 0.7625

Epoch 00037: val_acc improved from 0.75562 to 0.76250, saving model to /co
ntent/drive/My Drive/Recognizing_Faces_in_the_Wild/20190824/vgg_face.h5
Epoch 38/100
200/200 [==============================] - 217s 1s/step - loss: 0.3423 - a
cc: 0.8469 - val_loss: 0.5180 - val_acc: 0.7506

Epoch 00038: val_acc did not improve from 0.76250
```

```
Epoch 39/100
200/200 [==============================] - 217s 1s/step - loss: 0.3372 - a
cc: 0.8491 - val_loss: 0.5432 - val_acc: 0.7438

Epoch 00039: val_acc did not improve from 0.76250
Epoch 40/100
200/200 [==============================] - 218s 1s/step - loss: 0.3421 - a
cc: 0.8403 - val_loss: 0.5292 - val_acc: 0.7444

Epoch 00040: val_acc did not improve from 0.76250
Epoch 41/100
200/200 [==============================] - 218s 1s/step - loss: 0.3350 - a
cc: 0.8519 - val_loss: 0.5316 - val_acc: 0.7656

Epoch 00041: val_acc improved from 0.76250 to 0.76562, saving model to /co
ntent/drive/My Drive/Recognizing_Faces_in_the_Wild/20190824/vgg_face.h5
Epoch 42/100
200/200 [==============================] - 217s 1s/step - loss: 0.3281 - a
cc: 0.8562 - val_loss: 0.5189 - val_acc: 0.7550

Epoch 00042: val_acc did not improve from 0.76562
Epoch 43/100
200/200 [==============================] - 217s 1s/step - loss: 0.3217 - a
cc: 0.8562 - val_loss: 0.5104 - val_acc: 0.7688

Epoch 00043: val_acc improved from 0.76562 to 0.76875, saving model to /co
ntent/drive/My Drive/Recognizing_Faces_in_the_Wild/20190824/vgg_face.h5
Epoch 44/100
200/200 [==============================] - 217s 1s/step - loss: 0.3195 - a
cc: 0.8619 - val_loss: 0.5289 - val_acc: 0.7594

Epoch 00044: val_acc did not improve from 0.76875
Epoch 45/100
200/200 [==============================] - 217s 1s/step - loss: 0.3217 - a
cc: 0.8594 - val_loss: 0.5167 - val_acc: 0.7688

Epoch 00045: val_acc did not improve from 0.76875
Epoch 46/100
200/200 [==============================] - 218s 1s/step - loss: 0.3085 - a
cc: 0.8659 - val_loss: 0.5231 - val_acc: 0.7700

Epoch 00046: val_acc improved from 0.76875 to 0.77000, saving model to /co
ntent/drive/My Drive/Recognizing_Faces_in_the_Wild/20190824/vgg_face.h5
Epoch 47/100
200/200 [==============================] - 218s 1s/step - loss: 0.3188 - a
cc: 0.8566 - val_loss: 0.5481 - val_acc: 0.7638

Epoch 00047: val_acc did not improve from 0.77000
Epoch 48/100
200/200 [==============================] - 217s 1s/step - loss: 0.3026 - a
cc: 0.8656 - val_loss: 0.5708 - val_acc: 0.7456

Epoch 00048: val_acc did not improve from 0.77000
Epoch 49/100
200/200 [==============================] - 217s 1s/step - loss: 0.3080 - a
cc: 0.8653 - val_loss: 0.5908 - val_acc: 0.7375

Epoch 00049: val_acc did not improve from 0.77000
Epoch 50/100
200/200 [==============================] - 217s 1s/step - loss: 0.3016 - a
cc: 0.8731 - val_loss: 0.6103 - val_acc: 0.7331
```

```
Epoch 00050: val_acc did not improve from 0.77000
Epoch 51/100
200/200 [==============================] - 217s 1s/step - loss: 0.2951 - a
cc: 0.8788 - val_loss: 0.5428 - val_acc: 0.7562

Epoch 00051: val_acc did not improve from 0.77000
Epoch 52/100
200/200 [==============================] - 218s 1s/step - loss: 0.2950 - a
cc: 0.8672 - val_loss: 0.5885 - val_acc: 0.7550

Epoch 00052: val_acc did not improve from 0.77000
Epoch 53/100
200/200 [==============================] - 217s 1s/step - loss: 0.2858 - a
cc: 0.8831 - val_loss: 0.5648 - val_acc: 0.7375

Epoch 00053: val_acc did not improve from 0.77000
Epoch 54/100
200/200 [==============================] - 218s 1s/step - loss: 0.2924 - a
cc: 0.8738 - val_loss: 0.5572 - val_acc: 0.7488

Epoch 00054: val_acc did not improve from 0.77000
Epoch 55/100
200/200 [==============================] - 217s 1s/step - loss: 0.2812 - a
cc: 0.8778 - val_loss: 0.5494 - val_acc: 0.7350

Epoch 00055: val_acc did not improve from 0.77000
Epoch 56/100
200/200 [==============================] - 217s 1s/step - loss: 0.2761 - a
cc: 0.8847 - val_loss: 0.5654 - val_acc: 0.7550

Epoch 00056: val_acc did not improve from 0.77000
Epoch 57/100
200/200 [==============================] - 218s 1s/step - loss: 0.2954 - a
cc: 0.8769 - val_loss: 0.5998 - val_acc: 0.7212

Epoch 00057: val_acc did not improve from 0.77000
Epoch 58/100
200/200 [==============================] - 217s 1s/step - loss: 0.2730 - a
cc: 0.8897 - val_loss: 0.5281 - val_acc: 0.7631

Epoch 00058: val_acc did not improve from 0.77000
Epoch 59/100
200/200 [==============================] - 216s 1s/step - loss: 0.2781 - a
cc: 0.8834 - val_loss: 0.5371 - val_acc: 0.7606

Epoch 00059: val_acc did not improve from 0.77000
Epoch 60/100
200/200 [==============================] - 215s 1s/step - loss: 0.2741 - a
cc: 0.8781 - val_loss: 0.5203 - val_acc: 0.7712

Epoch 00060: val_acc improved from 0.77000 to 0.77125, saving model to /co
ntent/drive/My Drive/Recognizing_Faces_in_the_Wild/20190824/vgg_face.h5
Epoch 61/100
200/200 [==============================] - 215s 1s/step - loss: 0.2742 - a
cc: 0.8769 - val_loss: 0.5291 - val_acc: 0.7662

Epoch 00061: val_acc did not improve from 0.77125
Epoch 62/100
200/200 [==============================] - 215s 1s/step - loss: 0.2416 - a
cc: 0.8997 - val_loss: 0.5408 - val_acc: 0.7569
```

```
Epoch 00062: val_acc did not improve from 0.77125
Epoch 63/100
200/200 [==============================] - 216s 1s/step - loss: 0.2606 - a
cc: 0.8887 - val_loss: 0.5836 - val_acc: 0.7519

Epoch 00063: val_acc did not improve from 0.77125
Epoch 64/100
200/200 [==============================] - 217s 1s/step - loss: 0.2487 - a
cc: 0.8947 - val_loss: 0.5691 - val_acc: 0.7569

Epoch 00064: val_acc did not improve from 0.77125
Epoch 65/100
200/200 [==============================] - 217s 1s/step - loss: 0.2779 - a
cc: 0.8822 - val_loss: 0.6135 - val_acc: 0.7556

Epoch 00065: val_acc did not improve from 0.77125
Epoch 66/100
200/200 [==============================] - 217s 1s/step - loss: 0.2517 - a
cc: 0.8884 - val_loss: 0.6338 - val_acc: 0.7225

Epoch 00066: val_acc did not improve from 0.77125
Epoch 67/100
200/200 [==============================] - 218s 1s/step - loss: 0.2510 - a
cc: 0.8947 - val_loss: 0.6476 - val_acc: 0.7188

Epoch 00067: val_acc did not improve from 0.77125
Epoch 68/100
200/200 [==============================] - 220s 1s/step - loss: 0.2547 - a
cc: 0.8922 - val_loss: 0.5922 - val_acc: 0.7400

Epoch 00068: val_acc did not improve from 0.77125
Epoch 69/100
200/200 [==============================] - 220s 1s/step - loss: 0.2627 - a
cc: 0.8922 - val_loss: 0.5574 - val_acc: 0.7512

Epoch 00069: val_acc did not improve from 0.77125
Epoch 70/100
200/200 [==============================] - 219s 1s/step - loss: 0.2556 - a
cc: 0.8928 - val_loss: 0.5817 - val_acc: 0.7594

Epoch 00070: val_acc did not improve from 0.77125
Epoch 71/100
200/200 [==============================] - 220s 1s/step - loss: 0.2352 - a
cc: 0.9056 - val_loss: 0.5882 - val_acc: 0.7494

Epoch 00071: val_acc did not improve from 0.77125
Epoch 72/100
200/200 [==============================] - 219s 1s/step - loss: 0.2346 - a
cc: 0.9072 - val_loss: 0.5722 - val_acc: 0.7519

Epoch 00072: val_acc did not improve from 0.77125
Epoch 73/100
200/200 [==============================] - 221s 1s/step - loss: 0.2307 - a
cc: 0.9047 - val_loss: 0.5837 - val_acc: 0.7600

Epoch 00073: val_acc did not improve from 0.77125
Epoch 74/100
200/200 [==============================] - 221s 1s/step - loss: 0.2233 - a
cc: 0.9156 - val_loss: 0.6744 - val_acc: 0.7219
```

```
Epoch 00074: val_acc did not improve from 0.77125
Epoch 75/100
200/200 [==============================] - 221s 1s/step - loss: 0.2204 - a
cc: 0.9131 - val_loss: 0.6139 - val_acc: 0.7469

Epoch 00075: val_acc did not improve from 0.77125
Epoch 76/100
200/200 [==============================] - 220s 1s/step - loss: 0.2286 - a
cc: 0.9038 - val_loss: 0.5780 - val_acc: 0.7669

Epoch 00076: val_acc did not improve from 0.77125
Epoch 77/100
200/200 [==============================] - 220s 1s/step - loss: 0.2263 - a
cc: 0.9091 - val_loss: 0.6923 - val_acc: 0.7188

Epoch 00077: val_acc did not improve from 0.77125
Epoch 78/100
200/200 [==============================] - 220s 1s/step - loss: 0.2358 - a
cc: 0.9050 - val_loss: 0.5899 - val_acc: 0.7525

Epoch 00078: val_acc did not improve from 0.77125
Epoch 79/100
200/200 [==============================] - 220s 1s/step - loss: 0.2392 - a
cc: 0.9084 - val_loss: 0.5544 - val_acc: 0.7588

Epoch 00079: val_acc did not improve from 0.77125
Epoch 80/100
200/200 [==============================] - 220s 1s/step - loss: 0.2224 - a
cc: 0.9084 - val_loss: 0.6809 - val_acc: 0.7206

Epoch 00080: val_acc did not improve from 0.77125

Epoch 00080: ReduceLROnPlateau reducing learning rate to 9.999999747378752
e-07.
Epoch 81/100
200/200 [==============================] - 219s 1s/step - loss: 0.2132 - a
cc: 0.9134 - val_loss: 0.6425 - val_acc: 0.7419

Epoch 00081: val_acc did not improve from 0.77125
Epoch 82/100
200/200 [==============================] - 218s 1s/step - loss: 0.2076 - a
cc: 0.9203 - val_loss: 0.6043 - val_acc: 0.7569

Epoch 00082: val_acc did not improve from 0.77125
Epoch 83/100
200/200 [==============================] - 219s 1s/step - loss: 0.1940 - a
cc: 0.9266 - val_loss: 0.6390 - val_acc: 0.7506

Epoch 00083: val_acc did not improve from 0.77125
Epoch 84/100
200/200 [==============================] - 218s 1s/step - loss: 0.2066 - a
cc: 0.9191 - val_loss: 0.6349 - val_acc: 0.7369

Epoch 00084: val_acc did not improve from 0.77125
Epoch 85/100
200/200 [==============================] - 218s 1s/step - loss: 0.1928 - a
cc: 0.9288 - val_loss: 0.6372 - val_acc: 0.7375

Epoch 00085: val_acc did not improve from 0.77125
Epoch 86/100
200/200 [==============================] - 218s 1s/step - loss: 0.1713 - a
```

```
cc: 0.9341 - val_loss: 0.6413 - val_acc: 0.7438

Epoch 00086: val_acc did not improve from 0.77125
Epoch 87/100
200/200 [==============================] - 218s 1s/step - loss: 0.1877 - a
cc: 0.9269 - val_loss: 0.6674 - val_acc: 0.7294

Epoch 00087: val_acc did not improve from 0.77125
Epoch 88/100
200/200 [==============================] - 218s 1s/step - loss: 0.1787 - a
cc: 0.9341 - val_loss: 0.6138 - val_acc: 0.7469

Epoch 00088: val_acc did not improve from 0.77125
Epoch 89/100
200/200 [==============================] - 218s 1s/step - loss: 0.1866 - a
cc: 0.9300 - val_loss: 0.6636 - val_acc: 0.7356

Epoch 00089: val_acc did not improve from 0.77125
Epoch 90/100
200/200 [==============================] - 218s 1s/step - loss: 0.1723 - a
cc: 0.9378 - val_loss: 0.6543 - val_acc: 0.7462

Epoch 00090: val_acc did not improve from 0.77125
Epoch 91/100
200/200 [==============================] - 218s 1s/step - loss: 0.1800 - a
cc: 0.9313 - val_loss: 0.6855 - val_acc: 0.7300

Epoch 00091: val_acc did not improve from 0.77125
Epoch 92/100
200/200 [==============================] - 217s 1s/step - loss: 0.1707 - a
cc: 0.9322 - val_loss: 0.7071 - val_acc: 0.7394

Epoch 00092: val_acc did not improve from 0.77125
Epoch 93/100
200/200 [==============================] - 217s 1s/step - loss: 0.1698 - a
cc: 0.9378 - val_loss: 0.7594 - val_acc: 0.7163

Epoch 00093: val_acc did not improve from 0.77125
Epoch 94/100
200/200 [==============================] - 217s 1s/step - loss: 0.1859 - a
cc: 0.9250 - val_loss: 0.7116 - val_acc: 0.7275

Epoch 00094: val_acc did not improve from 0.77125
Epoch 95/100
200/200 [==============================] - 217s 1s/step - loss: 0.1700 - a
cc: 0.9350 - val_loss: 0.5837 - val_acc: 0.7588

Epoch 00095: val_acc did not improve from 0.77125
Epoch 96/100
200/200 [==============================] - 217s 1s/step - loss: 0.1718 - a
cc: 0.9366 - val_loss: 0.6641 - val_acc: 0.7388

Epoch 00096: val_acc did not improve from 0.77125
Epoch 97/100
200/200 [==============================] - 217s 1s/step - loss: 0.1795 - a
cc: 0.9313 - val_loss: 0.6765 - val_acc: 0.7375

Epoch 00097: val_acc did not improve from 0.77125
Epoch 98/100
200/200 [==============================] - 216s 1s/step - loss: 0.1682 - a
cc: 0.9359 - val_loss: 0.6770 - val_acc: 0.7306
```

```
Epoch 00098: val_acc did not improve from 0.77125
Epoch 99/100
200/200 [==============================] - 217s 1s/step - loss: 0.1689 - a
cc: 0.9363 - val_loss: 0.7014 - val_acc: 0.7356

Epoch 00099: val_acc did not improve from 0.77125
Epoch 100/100
200/200 [==============================] - 217s 1s/step - loss: 0.1632 - a
cc: 0.9384 - val_loss: 0.7112 - val_acc: 0.7256

Epoch 00100: val_acc did not improve from 0.77125

Epoch 00100: ReduceLROnPlateau reducing learning rate to 9.999999974752428
e-08.
```

In [0]:

```
import pickle
with open('/content/drive/My Drive/Recognizing_Faces_in_the_Wild/20190824/history.pkl',
'wb') as f:
  pickle.dump(history,f)
```

In [0]:

```
#saving the model
model.save('/content/drive/My Drive/Recognizing_Faces_in_the_Wild/20190824/vggface.h5')
```

In [0]:

```
model=load_model('/content/drive/My Drive/Recognizing_Faces_in_the_Wild/20190824/vggfac
e.h5')
```

In [0]:

```
test_path='/content/drive/My Drive/Recognizing_Faces_in_the_Wild/test/'
```

In [0]:

```
submission=pd.read_csv('/content/drive/My Drive/Recognizing_Faces_in_the_Wild/sample_su
bmission.csv',header=0)
```

In [24]:

```
submission.head()
```

Out[24]:

	img_pair	is_related
0	face05508.jpg-face01210.jpg	0
1	face05750.jpg-face00898.jpg	0
2	face05820.jpg-face03938.jpg	0
3	face02104.jpg-face01172.jpg	0
4	face02428.jpg-face05611.jpg	0

In [0]:

```
#generates test data in batches
def test_batch(test_pairs,size=32):
  return (test_pairs[pos:pos+size] for pos in range(0,len(test_pairs),size))
```

In [26]:

```
predictions=[]

for batch in tqdm(test_batch(submission.img_pair.values)):
    X1 = [x.split("-")[0] for x in batch]
    X1 = np.array([img2arr(test_path + x) for x in X1])

    X2 = [x.split("-")[1] for x in batch]
    X2 = np.array([img2arr(test_path + x) for x in X2])

    pred = model.predict([X1, X2]).ravel().tolist()
    predictions += pred

submission['is_related'] = predictions
```

```
166it [33:40, 10.38s/it]
```

In [0]:

```
submission.to_csv("/content/drive/My Drive/Recognizing_Faces_in_the_Wild/20190824/predi
ctions.csv", index=False)
```

Note

Used features (x1-x2)^2, (x1^2 - x2^2) and (x1*x2)

Used different validation sets while training five models and took the average of predictions of all models to improve the score.