Face Recognition against My Photo Library

The iCloud photos from iOS or Mac OS provided a comprenesive way to tag faces and then all the photos in the library will be scanned, faces will be identified and tagged accordingly based on the earlier user defined tags.

I am a photography enthusiast and I have started to taking photos from year 2004. As of today, it's over 200k shots and I've kept 40k of them. There are many desktop applications can do the job of face recognition, but it's going to be super fun if I can build the solution end to end.

This report will have following parts.

1. Get photos and preprocess.
2. Get the features of the baseine photos.
3. Train the model to perform the classification.
4. Evaluate the model.

Part 1 - Get photos and preprocessing

A glance at the folder structure

All my photos are in `D:\Pictures`, majority of them are in both `.jpg` and `.nef` format. The `.nef` is a raw image format for Nikon cameras and `.jpg` is the copy after image post-processing of raw file.

In [1]:
```
import os
import time
cur_dir = os.getcwd()
print(cur_dir)
target_image_dir = os.path.join(cur_dir, 'images')
photo_dir = 'D:\Pictures'
os.listdir(photo_dir)
```

```
D:\Google Drive\Study\Deep Learning Developer\Projects\Project 4 - Face Recognition Against My Photo Library
```

Out[1]:
```
['.SynologyWorkingDirectory',
 '2004',
 '2005',
 '2006',
 '2007',
 '2008',
 '2009',
 '2010',
 '2011',
 '2012',
 '2013',
 '2014',
 '2015',
 '2016',
 '2017',
 'Adobe Lightroom',
 'Camera Roll',
 'desktop.ini',
 'iCloud Photos',
 'naming instruction.txt',
 'Phone Photos',
 'Photography Works',
 'Saved Pictures',
 'zbingjie',
 'zothers',
 '法蝶',
 '熊思宇和黄乐论辩论']
```

One sample of a recent photo directory. Each and every file use the time stamp as its file name. `.nef` is the raw image file, `.xmp` is generated by Adobe Lightroom, both are not applicable to this project.

In [2]:
```
os.listdir(photo_dir + '/2017/2017.11.16 - Singapore Fintech Festival')
```

Out[2]:
```
['20171112-2038.jpg',
 '20171112-2038.NEF',
 '20171112-2038.xmp',
 '20171112-2039.jpg',
 '20171112-2039.NEF',
 '20171112-2039.xmp',
 '20171116-1705.jpg',
 '20171116-1705.NEF',
 '20171116-1705.xmp',
 '20171116-1707.jpg',
 '20171116-1707.NEF',
 '20171116-1707.xmp',
 '20171116-1708.jpg',
 '20171116-1708.NEF',
 '20171116-1708.xmp',
 '20171116-1709.jpg',
 '20171116-1709.NEF',
 '20171116-1709.xmp',
 '20171116-1710.jpg',
```

Create face images

Iteratively going through all the images and save the face to a jpg file into the working directory. The value of the scaling factor in the cascade classifier affects the number of false positive. Some manual process will be needed.

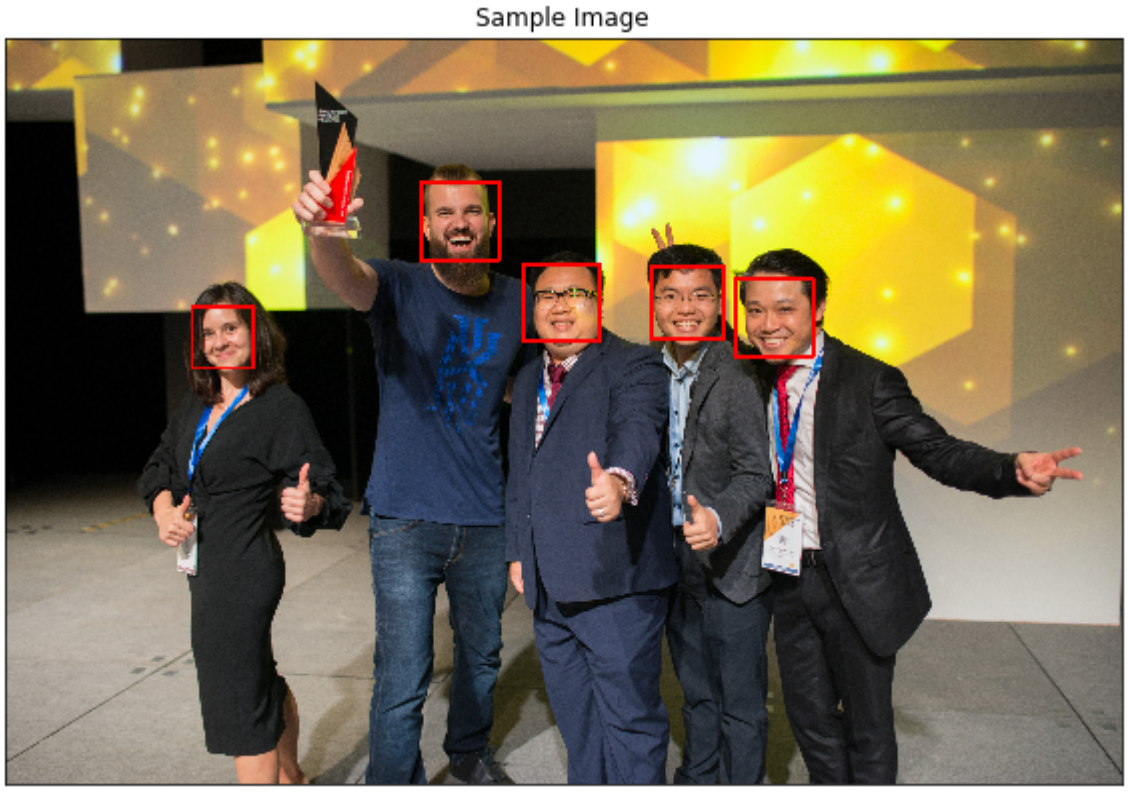
In [120]:
```
# Import required libraries for this section
%matplotlib inline
import numpy as np
import matplotlib.pyplot as plt
import math
import cv2
import time
```

In [64]:
```
def show_faces(file_path, display=False, save=False, scaleFactor=1.3, minNeighb=5):
    print('Image path', file_path)

    # The file path contains unicode characters, cannot use cv2.imread() directly
    file_stream = open(file_path, 'rb')
    bytes_arr = bytearray(file_stream.read())
    numpy_ar = np.asarray(bytes_arr, dtype=np.uint8)
    image = cv2.imdecode(numpy_ar, cv2.IMREAD_UNCHANGED)
    print(image.shape)

    # Convert to RGB
    image = cv2.cvtColor(image, cv2.COLOR_BGR2RGB)
    # Convert the RGB  image to grayscale
    gray = cv2.cvtColor(image, cv2.COLOR_RGB2GRAY)

    # Extract the pre-trained face detector from an xml file
    face_cascade = cv2.CascadeClassifier('detector_architectures/haarcascade_frontalface_default.xml')

    # Detect the faces in image
    faces = face_cascade.detectMultiScale(gray, scaleFactor, minNeighb)

    # Print the number of faces detected in the image
    print('Number of faces detected:', len(faces))

    # Make a copy of the orginal image to draw face detections on
    image_with_detections = np.copy(image)

    # The list of detected faces
    image_faces = []
    # Get the bounding box for each detected face
    for (x,y,w,h) in faces:
        # Add a red bounding box to the detections image
        if w > 200:
            line_width = w//20
        else:
            line_width = 3
        image_faces.append(image[y:(y+h), x:(x+w)])
        cv2.rectangle(image_with_detections, (x,y), (x+w,y+h), (255,0,0), line_width)

    if save:
        save_faces(file_path, image_faces)

    if display:
        # Display the image with the detections
        fig = plt.figure(figsize=(10, 10))
        ax = fig.add_subplot(1, 1, 1, xticks=[], yticks=[])
        ax.set_title('Sample Image')
        ax.imshow(image_with_detections)
    os.chdir(cur_dir)
```

In [5]:
```
# pathlib available from python 3.5
from pathlib import Path
def save_faces(file_path, image_faces):
    if len(image_faces) == 0:
        return
    # Save the each face into individual files
    target_file = file_path.replace(photo_dir, target_image_dir)
    target_dir = os.path.dirname(target_file)
    target_path = Path(target_dir)

    # Create parents of directory, don't raise exception if the directory exists
    target_path.mkdir(parents=True, exist_ok=True)

    for i, face in enumerate(image_faces):
        face = cv2.resize(face, (299, 299))
        os.chdir(target_dir)
        file_name = os.path.basename(target_file)
        cv2.imwrite(file_name + '-face-' + str(i) + '.jpg', cv2.cvtColor(face, cv2.COLOR_BGR2RGB))
```

In [65]:
```
# Load in color image for face detection
file_path = os.path.join(photo_dir, '2017\\2017.11.16 - Singapore Fintech Festival', '20171116-1923.jpg')
show_faces(file_path, True)
```

```
Image path D:\Pictures\2017\2017.11.16 - Singapore Fintech Festival\20171116-1923.jpg
(4760, 7132, 3)
Number of faces detected: 5
```



In [6]:
```
all_jpg = []
for root, dirs, files in os.walk(photo_dir):
    # All the target photos are in D:\Pictures\20xx. Get the jpgs from them only.
    path = root.split(os.sep)
    if len(path) < 3:
        continue
    else:
        year = path[2]
        if year[:2] != '20':
            continue
    #print((len(path) - 1) * '---', os.path.basename(root))
    for file in files:
        if file[-3:].lower() == 'jpg':
            #print(len(path) * '---', file)
            all_jpg.append(os.path.join(root, file))
```

In [7]:
```
print('Number of jpgs:', len(all_jpg))
all_jpg[:10]
```

```
Number of jpgs: 39687
```

Out[7]:
```
['D:\\Pictures\\2004\\2004.12.16 - 保存的第一张数码照片\\20041216-2037.JPG',
 'D:\\Pictures\\2004\\2004.12.21~24 - 刚到新加坡，bukit timah hill, befriender, 猴子, oldham hall及附近\\20041221
-0828.jpg',
 'D:\\Pictures\\2004\\2004.12.21~24 - 刚到新加坡，bukit timah hill, befriender, 猴子, oldham hall及附近\\20041221
-0829.jpg',
 'D:\\Pictures\\2004\\2004.12.21~24 - 刚到新加坡，bukit timah hill, befriender, 猴子, oldham hall及附近\\20041221
-1004.jpg',
 'D:\\Pictures\\2004\\2004.12.21~24 - 刚到新加坡，bukit timah hill, befriender, 猴子, oldham hall及附近\\20041221
-1011-2.jpg',
 'D:\\Pictures\\2004\\2004.12.21~24 - 刚到新加坡，bukit timah hill, befriender, 猴子, oldham hall及附近\\20041221
-1011.jpg',
 'D:\\Pictures\\2004\\2004.12.21~24 - 刚到新加坡，bukit timah hill, befriender, 猴子, oldham hall及附近\\20041221
-1013.jpg',
 'D:\\Pictures\\2004\\2004.12.21~24 - 刚到新加坡，bukit timah hill, befriender, 猴子, oldham hall及附近\\20041221
-1203.jpg',
 'D:\\Pictures\\2004\\2004.12.21~24 - 刚到新加坡，bukit timah hill, befriender, 猴子, oldham hall及附近\\20041221
-1219.jpg',
 'D:\\Pictures\\2004\\2004.12.21~24 - 刚到新加坡，bukit timah hill, befriender, 猴子, oldham hall及附近\\20041221
-1225.jpg']
```

In [ ]:
```
##############################
### RUN WITH CAUSION#########
##############################

# Scan through all 40k photos and extract faces
for i in range(len(all_jpg)):
    show_faces(all_jpg[i], False, True)
```

Manully label the face images by putting them into different folders

There are 100k faces identified. Most of them are non-relevant. I hand picked over 200 of them.

In [8]:
```
os.listdir('./images')
```

Out[8]:
```
['Test', 'Train', 'Validate']
```

In [9]:
```
os.listdir('./images/Test')
```

Out[9]:
```
['Brother', 'Dad', 'Daughter', 'Me', 'Mum', 'Son', 'Wife']
```

In [10]:
```
from sklearn.datasets import load_files
from keras.utils import np_utils
from glob import glob

# Read all the files and return 2 numpy arrays, 1 is the address of the files
# and 1 is the one hot encode of the category.
def load_dataset(path):
    data = load_files(path)
    face_files = np.array(data['filenames'])
    face_targets = np_utils.to_categorical(np.array(data['target']), 7)
    return face_files, face_targets
```

```
Using TensorFlow backend.
```

Part 2 - Transfer learning and train the model

In [36]:
```
from keras.applications.inception_v3 import InceptionV3
from keras.models import Model
from keras.layers import Dense, GlobalAveragePooling2D
from keras import backend as K
from keras.applications.imagenet_utils import preprocess_input, decode_predictions
from keras.callbacks import ModelCheckpoint, EarlyStopping, LambdaCallback, ReduceLROnPlateau
from keras.models import load_model
```

In [12]:
```
base_model = InceptionV3(weights='imagenet', include_top=False)
base_model.summary()
```

```
____________________________________________________________________________________________________
Layer (type)                     Output Shape          Param #     Connected to
====================================================================================================
input_1 (InputLayer)             (None, None, None, 3) 0
____________________________________________________________________________________________________
conv2d_1 (Conv2D)                (None, None, None, 32 864         input_1[0][0]
____________________________________________________________________________________________________
batch_normalization_1 (BatchNorm (None, None, None, 32 96          conv2d_1[0][0]
____________________________________________________________________________________________________
activation_1 (Activation)        (None, None, None, 32 0           batch_normalization_1[0][0]
____________________________________________________________________________________________________
conv2d_2 (Conv2D)                (None, None, None, 32 9216        activation_1[0][0]
____________________________________________________________________________________________________
batch_normalization_2 (BatchNorm (None, None, None, 32 96          conv2d_2[0][0]
____________________________________________________________________________________________________
activation_2 (Activation)        (None, None, None, 32 0           batch_normalization_2[0][0]
____________________________________________________________________________________________________
conv2d_3 (Conv2D)                (None, None, None, 64 18432       activation_2[0][0]
____________________________________________________________________________________________________
```

In [13]:
```
for layer in base_model.layers:
    layer.trainable = False
```

In [21]:
```
x = base_model.output
x = GlobalAveragePooling2D()(x)
x = Dense(1000, activation = 'relu')(x)
x = Dense(200, activation = 'relu')(x)
x = Dense(50, activation = 'relu')(x)
x = Dense(7, activation = 'softmax')(x)

my_model_1 = Model(inputs = base_model.input, outputs = x)
my_model_1.summary()
```

```
____________________________________________________________________________________________________
Layer (type)                     Output Shape          Param #     Connected to
====================================================================================================
input_1 (InputLayer)             (None, None, None, 3) 0
____________________________________________________________________________________________________
conv2d_1 (Conv2D)                (None, None, None, 32 864         input_1[0][0]
____________________________________________________________________________________________________
batch_normalization_1 (BatchNorm (None, None, None, 32 96          conv2d_1[0][0]
____________________________________________________________________________________________________
activation_1 (Activation)        (None, None, None, 32 0           batch_normalization_1[0][0]
____________________________________________________________________________________________________
conv2d_2 (Conv2D)                (None, None, None, 32 9216        activation_1[0][0]
____________________________________________________________________________________________________
batch_normalization_2 (BatchNorm (None, None, None, 32 96          conv2d_2[0][0]
____________________________________________________________________________________________________
activation_2 (Activation)        (None, None, None, 32 0           batch_normalization_2[0][0]
____________________________________________________________________________________________________
conv2d_3 (Conv2D)                (None, None, None, 64 18432       activation_2[0][0]
____________________________________________________________________________________________________
```

In [39]:
```
# Load the list of images and categories
train_faces, train_targets = load_dataset('./images-fewer/Train')
test_faces, test_targets = load_dataset('./images-fewer/Test')
validate_faces, validate_targets = load_dataset('./images-fewer/Validate')

face_names = [item[15:-1] for item in glob('./images-fewer/Train/*/')]

print('There are %d face categories.' % len(face_names))
print(face_names)
print('There are %d total faces.' % len(np.hstack([train_faces, test_faces, validate_faces])))
print('There are %d training faces.' % len(train_faces))
print('There are %d test faces.' % len(test_faces))
print('There are %d validate faces.' % len(validate_faces))
```

```
There are 7 face categories.
['Train\\Brother', 'Train\\Dad', 'Train\\Daughter', 'Train\\Me', 'Train\\Mum', 'Train\\Son', 'Train\\Wife']
There are 263 total faces.
There are 148 training faces.
There are 58 test faces.
There are 57 validate faces.
```

In [40]:
```
from keras.preprocessing import image

def path_to_tensor(img_path):
    img = image.load_img(img_path, target_size=(299,299))
    x = image.img_to_array(img)
    return np.expand_dims(x, axis=0)

def paths_to_tensor(img_paths):
    list_of_tensors = [path_to_tensor(img_path) for img_path in img_paths]
    return np.vstack(list_of_tensors)
```

In [41]:
```
# Read the images as numpy arrays
train_tensors = paths_to_tensor(train_faces).astype('float32')/255
test_tensors = paths_to_tensor(test_faces).astype('float32')/255
validate_tensors = paths_to_tensor(validate_faces).astype('float32')/255
print("Train tensor shape.", train_tensors.shape)
print('Test tensor shape.', test_tensors.shape)
print('Validate tensor shape.', validate_tensors.shape)
```

```
Train tensor shape. (148, 299, 299, 3)
Test tensor shape. (58, 299, 299, 3)
Validate tensor shape. (57, 299, 299, 3)
```

In [26]:
```
my_model_1.compile(optimizer='rmsprop', loss='categorical_crossentropy', metrics=['accuracy'])
checkpointer = ModelCheckpoint(filepath='my_model_1.h5',
                               verbose=1, save_best_only=True)
early_stopping = EarlyStopping(monitor='val_loss', min_delta=0, patience=30, verbose=1, mode='auto')
reduce_lr = ReduceLROnPlateau(monitor='val_loss', factor=0.9, patience=10, cooldown=0, min_lr=0.00001)
lr_print = LambdaCallback(on_epoch_begin=lambda epoch, logs: print('lr:', K.eval(my_model_1.optimizer.lr)))
```

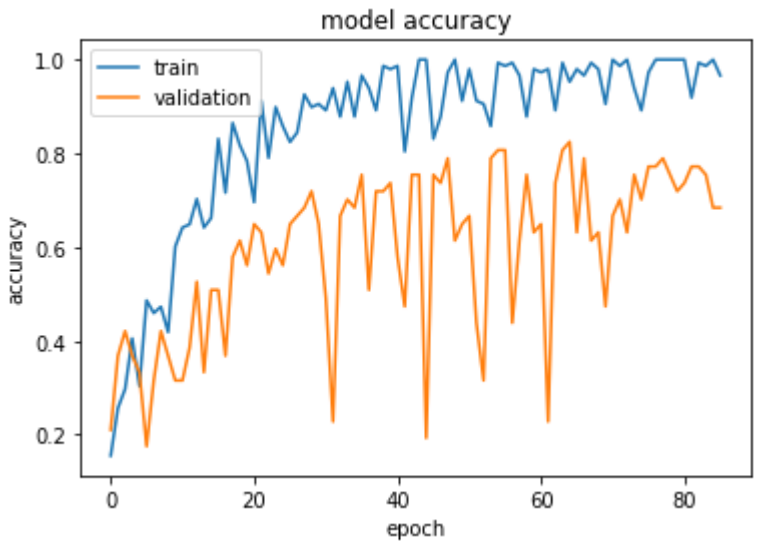
In [27]:
```
hist_1 = my_model_1.fit(train_tensors, train_targets,
           validation_data=(validate_tensors, validate_targets),
           epochs=200, verbose=1, batch_size=20,
           callbacks=[checkpointer, early_stopping, reduce_lr, lr_print])
```

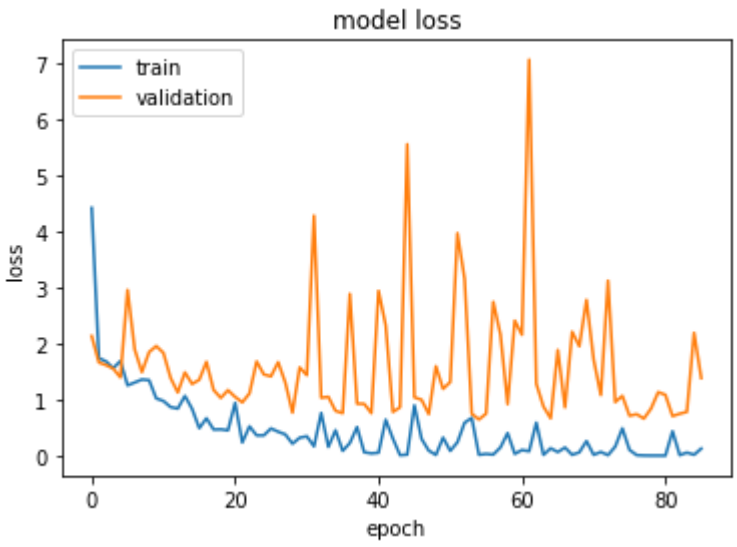
```
Epoch 33/200
140/148 [===========================>..] - ETA: 0s - loss: 0.4695 - acc: 0.8714Epoch 00034: val_loss did not
improve
148/148 [==============================] - 1s - loss: 0.4532 - acc: 0.8784 - val_loss: 0.8000 - val_acc: 0.68
42
lr: 0.001
Epoch 36/200
140/148 [===========================>..] - ETA: 0s - loss: 0.0893 - acc: 0.9643Epoch 00035: val_loss improved
from 0.76887 to 0.75875, saving model to my_model_1.h5
148/148 [==============================] - 2s - loss: 0.0861 - acc: 0.9662 - val_loss: 0.7587 - val_acc: 0.75
44
lr: 0.001
Epoch 37/200
140/148 [===========================>..] - ETA: 0s - loss: 0.1787 - acc: 0.9643Epoch 00036: val_loss did not
improve
148/148 [==============================] - 1s - loss: 0.2268 - acc: 0.9392 - val_loss: 2.8882 - val_acc: 0.50
88
lr: 0.001
Epoch 38/200
140/148 [===========================>..] - ETA: 0s - loss: 0.5084 - acc: 0.8929Epoch 00037: val_loss did not
```

In [28]:
```
## TODO: Visualize the training and validation loss of your neural network
import matplotlib.pyplot as plt
def plt_hist(hist):
    print(hist.history.keys())
    # summarize history for accuracy
    plt.plot(hist.history['acc'])
    plt.plot(hist.history['val_acc'])
    plt.title('model accuracy')
    plt.ylabel('accuracy')
    plt.xlabel('epoch')
    plt.legend(['train', 'validation'], loc='upper left')
    plt.show()
    # summarize history for loss
    plt.plot(hist.history['loss'])
    plt.plot(hist.history['val_loss'])
    plt.title('model loss')
    plt.ylabel('loss')
    plt.xlabel('epoch')
    plt.legend(['train', 'validation'], loc='upper left')
    plt.show()
```

In [29]:
```
plt_hist(hist_1)
```

```
dict_keys(['loss', 'val_loss', 'val_acc', 'acc', 'lr'])
```





In [42]:
```
my_model_1 = load_model('./my_model_1.h5')
score = my_model_1.evaluate(test_tensors, test_targets, verbose=1)
print('Test loss:', score[0])
print('Test accuracy:', score[1])
```

```
58/58 [==============================] - 3s
Test loss: 0.36949106126
Test accuracy: 0.844827617037
```

The testing accuracy is 84.5%, lower than I expected as there is only 7 classes. I tried to fine tune the number of layers and neurons in the dense layers, but didn't improve much. Maybe it's due to too limited number of images.

Part 3 - Improve accuracy with more images

More images were added to existing folder, just need to refresh the tensors and models.

In [79]:
```
# Load the list of images and categories
train_faces, train_targets = load_dataset('./images/Train')
test_faces, test_targets = load_dataset('./images/Test')
validate_faces, validate_targets = load_dataset('./images/Validate')

face_names = [item[15:-1] for item in glob('./images/Train/*/')]

print(face_names)
print('There are %d face categories.' % len(face_names))
print('There are %d total faces.' % len(np.hstack([train_faces, test_faces, validate_faces])))
print('There are %d training faces.' % len(train_faces))
print('There are %d test faces.' % len(test_faces))
print('There are %d validate faces.' % len(validate_faces))
```

```
['Brother', 'Dad', 'Daughter', 'Me', 'Mum', 'Son', 'Wife']
There are 7 face categories.
There are 428 total faces.
There are 257 training faces.
There are 98 test faces.
There are 73 validate faces.
```

In [82]:
```
print(train_faces[0], train_targets[0])
print(np.argmax(train_targets[0]))
print(face_names[4])
```

```
./images/Train\Mum\20160805-2119.jpg-face-0.jpg [ 0.  0.  0.  0.  1.  0.  0.]
4
Mum
```

In [44]:
```
train_tensors = paths_to_tensor(train_faces).astype('float32')/255
test_tensors = paths_to_tensor(test_faces).astype('float32')/255
validate_tensors = paths_to_tensor(validate_faces).astype('float32')/255
print("Train tensor shape.", train_tensors.shape)
print('Test tensor shape.', test_tensors.shape)
print('Validate tensor shape.', validate_tensors.shape)
```

```
Train tensor shape. (257, 299, 299, 3)
Test tensor shape. (98, 299, 299, 3)
Validate tensor shape. (73, 299, 299, 3)
```

In [47]:
```
x = base_model.output
x = GlobalAveragePooling2D()(x)
x = Dense(1000, activation = 'relu')(x)
x = Dense(200, activation = 'relu')(x)
x = Dense(50, activation = 'relu')(x)
x = Dense(7, activation = 'softmax')(x)

my_model_2 = Model(inputs = base_model.input, outputs = x)
my_model_2.summary()
```

```
____________________________________________________________________________________________________
Layer (type)                     Output Shape          Param #     Connected to
====================================================================================================
input_1 (InputLayer)             (None, None, None, 3) 0
____________________________________________________________________________________________________
conv2d_1 (Conv2D)                (None, None, None, 32 864         input_1[0][0]
____________________________________________________________________________________________________
batch_normalization_1 (BatchNorm (None, None, None, 32 96          conv2d_1[0][0]
____________________________________________________________________________________________________
activation_1 (Activation)        (None, None, None, 32 0           batch_normalization_1[0][0]
____________________________________________________________________________________________________
conv2d_2 (Conv2D)                (None, None, None, 32 9216        activation_1[0][0]
____________________________________________________________________________________________________
batch_normalization_2 (BatchNorm (None, None, None, 32 96          conv2d_2[0][0]
____________________________________________________________________________________________________
activation_2 (Activation)        (None, None, None, 32 0           batch_normalization_2[0][0]
____________________________________________________________________________________________________
conv2d_3 (Conv2D)                (None, None, None, 64 18432       activation_2[0][0]
____________________________________________________________________________________________________
batch_normalization_3 (BatchNorm (None, None, None, 64 192         conv2d_3[0][0]
```

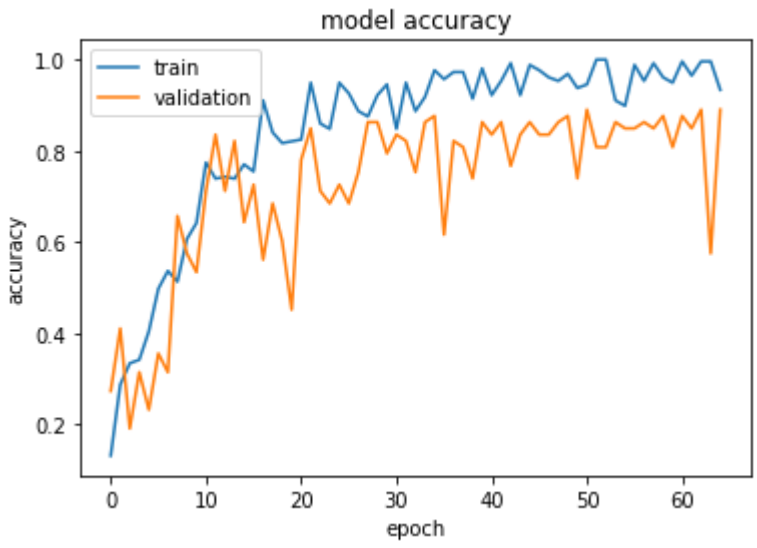
In [48]:
```
my_model_2.compile(optimizer='rmsprop', loss='categorical_crossentropy', metrics=['accuracy'])
checkpointer = ModelCheckpoint(filepath='my_model_2.h5',
                               verbose=1, save_best_only=True)
early_stopping = EarlyStopping(monitor='val_loss', min_delta=0, patience=30, verbose=1, mode='auto')
reduce_lr = ReduceLROnPlateau(monitor='val_loss', factor=0.9, patience=10, cooldown=0, min_lr=0.00001)
lr_print = LambdaCallback(on_epoch_begin=lambda epoch, logs: print('lr:', K.eval(my_model_2.optimizer.lr)))
```

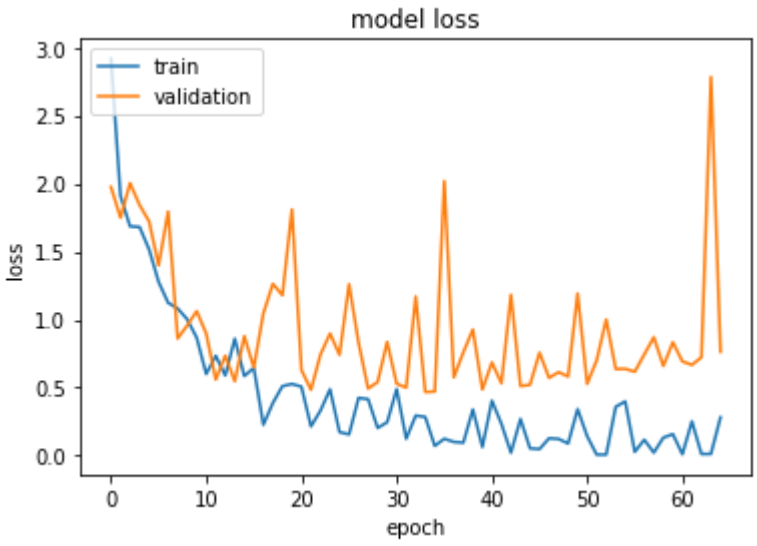
In [49]:
```
hist_2 = my_model_2.fit(train_tensors, train_targets,
            validation_data=(validate_tensors, validate_targets),
            epochs=200, verbose=1, batch_size=20,
            callbacks=[checkpointer, early_stopping, reduce_lr, lr_print])
```

```
240/257 [===========================>..] - ETA: 0s - loss: 0.0980 - acc: 0.9708Epoch 00037: val_loss did not
improve
257/257 [==============================] - 2s - loss: 0.0956 - acc: 0.9728 - val_loss: 0.7598 - val_acc: 0.80
82
lr: 0.0009
Epoch 39/200
240/257 [===========================>..] - ETA: 0s - loss: 0.3566 - acc: 0.9125Epoch 00038: val_loss did not
improve
257/257 [==============================] - 2s - loss: 0.3396 - acc: 0.9144 - val_loss: 0.9270 - val_acc: 0.73
97
lr: 0.0009
Epoch 40/200
240/257 [===========================>..] - ETA: 0s - loss: 0.0675 - acc: 0.9792Epoch 00039: val_loss did not
improve
257/257 [==============================] - 2s - loss: 0.0639 - acc: 0.9805 - val_loss: 0.4866 - val_acc: 0.86
30
lr: 0.0009
Epoch 41/200
240/257 [===========================>..] - ETA: 0s - loss: 0.4320 - acc: 0.9167Epoch 00040: val_loss did not
improve
```

In [50]:
```
plt_hist(hist_2)
```

```
dict_keys(['loss', 'val_loss', 'val_acc', 'acc', 'lr'])
```





In [52]:
```
my_model_2 = load_model('./my_model_2.h5')
```

In [53]:
```
score_2 = my_model_2.evaluate(test_tensors, test_targets, verbose=1)
print('Test loss:', score_2[0])
print('Test accuracy:', score_2[1])
```

```
96/98 [============================>.] - ETA: 0sTest loss: 0.32326669839
Test accuracy: 0.887755102041
```

In [54]:
```
score_1 = my_model_1.evaluate(test_tensors, test_targets, verbose=1)
print('Test loss:', score_1[0])
print('Test accuracy:', score_1[1])
```

```
96/98 [============================>.] - ETA: 0sTest loss: 0.547816322774
Test accuracy: 0.816326530612
```

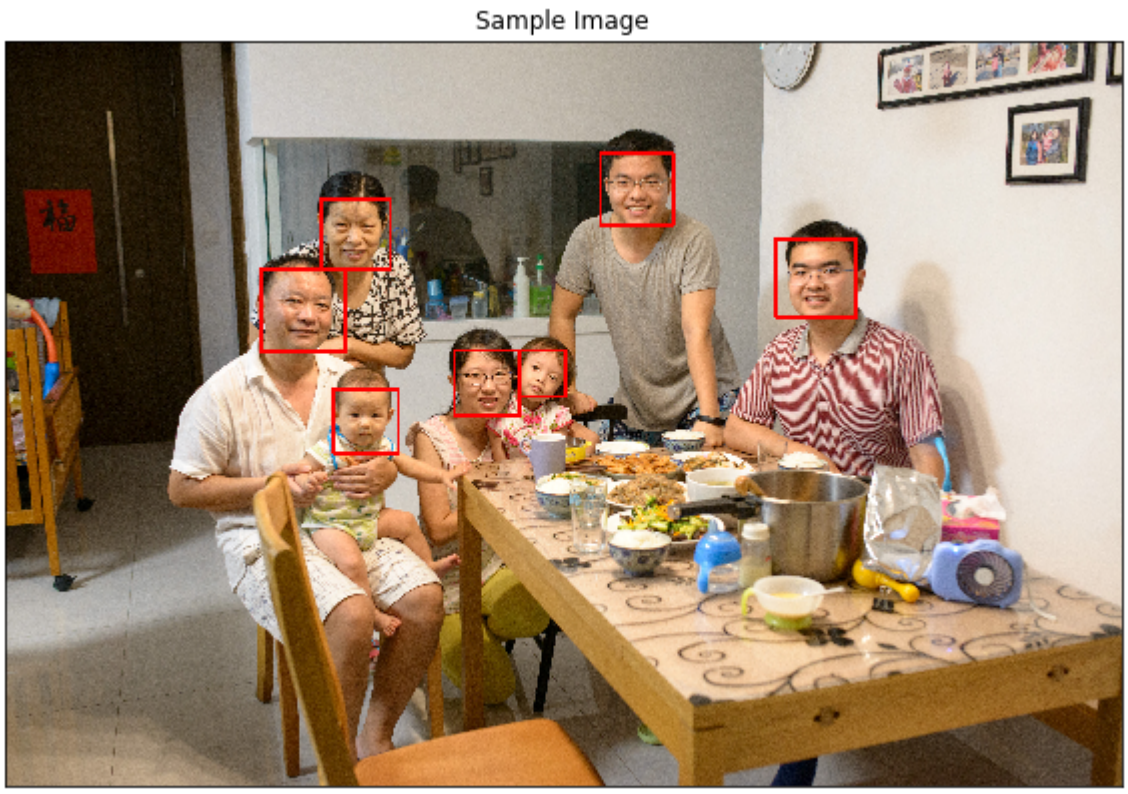
More data actually helps improve the accuracy. The second model shows 7% higher accuracy against the same set of testing data.

Part 4 - Face recognition on sample photos

There are two family photos 'test_1.jpg' and 'test_2.jpg' in the root of working directory never been used for training or testing in the earlier sections. Let's perform a face detection using the `show_faces()`.

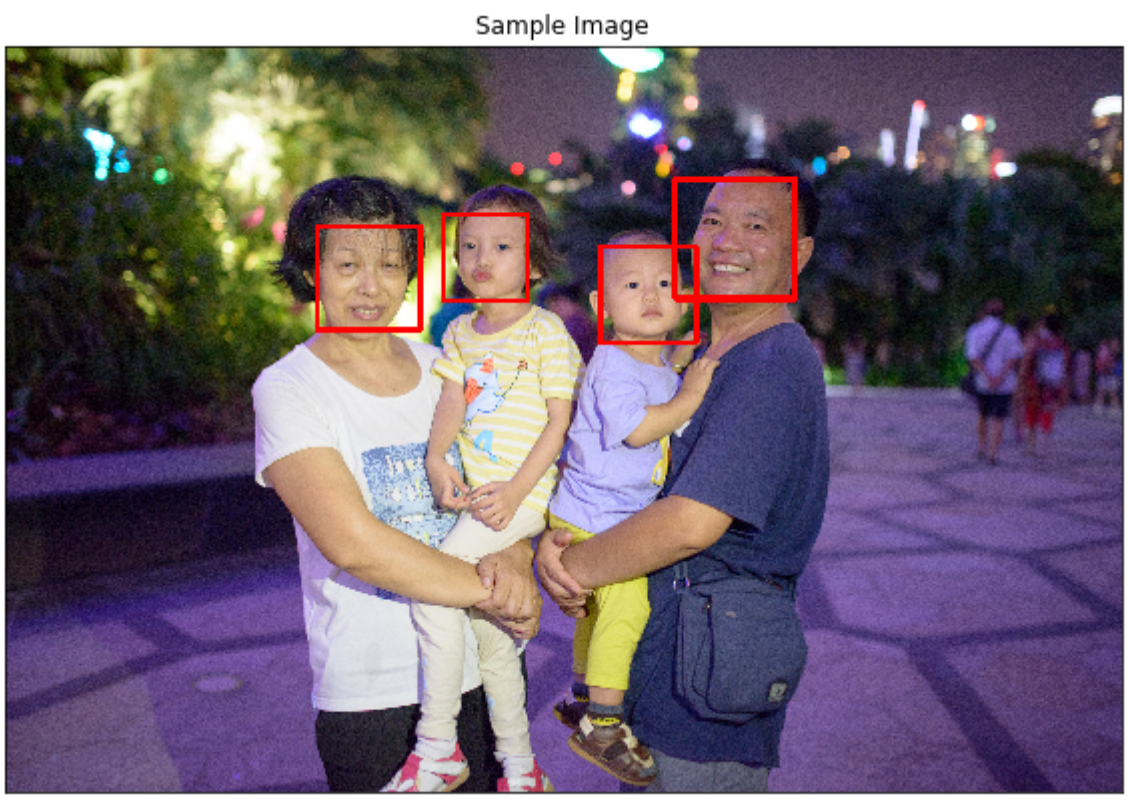
In [76]:
```
show_faces('./test_1.jpg', True, False, 1.3, 7)
```

```
Image path ./test_1.jpg
(4912, 7360, 3)
Number of faces detected: 7
```



In [77]:
```
show_faces('./test_2.jpg', True, False, 1.35, 5)
```

```
Image path ./test_2.jpg
(4766, 7141, 3)
Number of faces detected: 4
```



One test sample on using the model to predict and return the result as index of the `face_names`

In [147]:
```
one_test = test_tensors[56].reshape(-1, 299, 299, 3)
predict_idx = np.argmax(my_model_2.predict(one_test))
print(test_faces[56])
print(face_names)
print('The predicted face is: ', face_names[predict_idx])
```

```
./images/Test\Dad\20110204-1825.jpg-face-0.jpg
['Brother', 'Dad', 'Daughter', 'Me', 'Mum', 'Son', 'Wife']
The predicted face is:  Dad
```

Now let's make customized `detect_faces()` and `recognize_faces()`

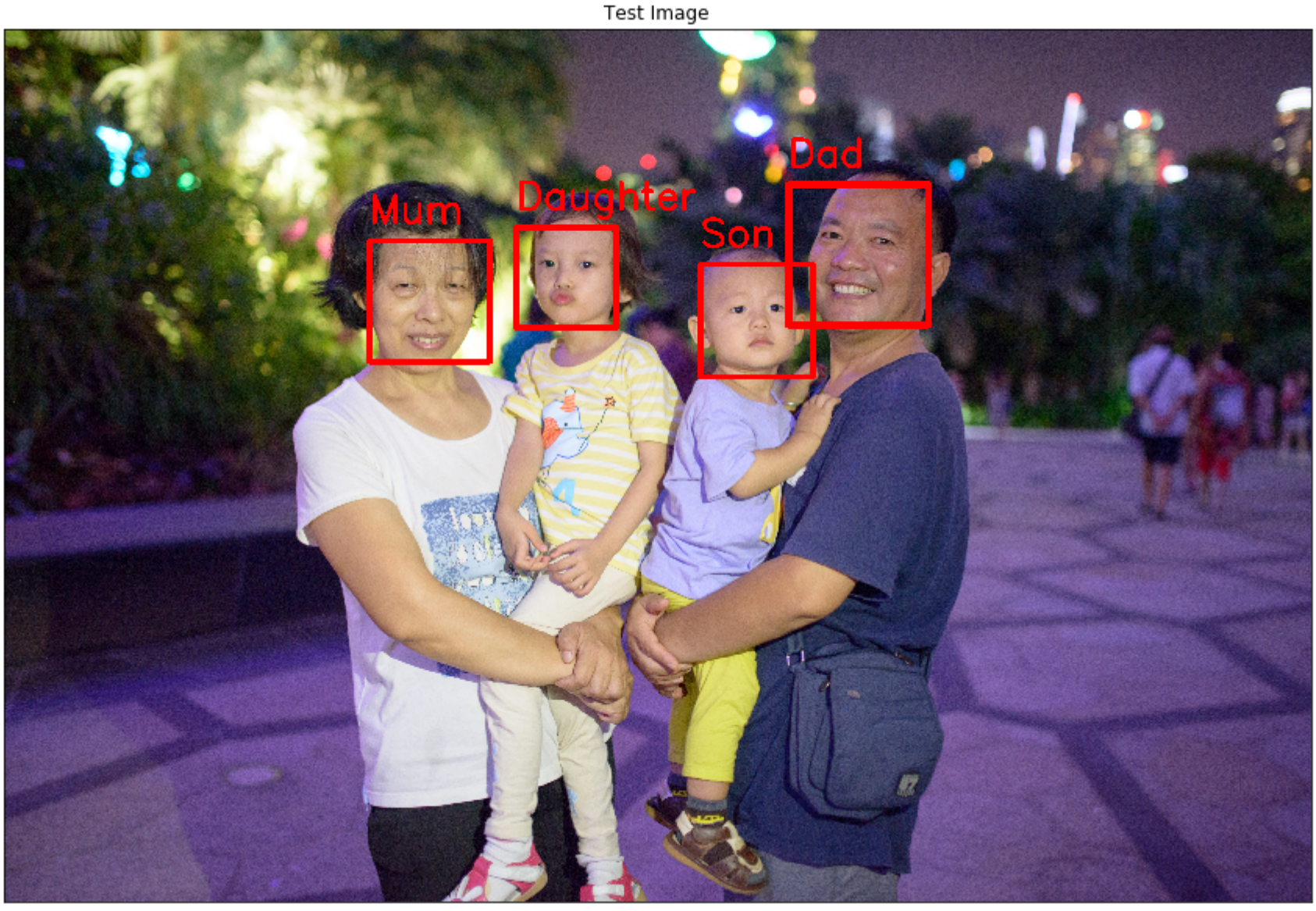
In [158]:
```
def recognize_face(image_face):
    # Conver the 3 channel RGB to 4-d tensor and normalize it
    image_face = image_face.reshape(-1, 299, 299, 3)/255
    predict_idx = np.argmax(my_model_2.predict(image_face))
    return face_names[predict_idx]
```

In [213]:
```
def detect_faces(file_path, display=False, recognize=False, scaleFactor=1.3, minNeighb=5):
    print('Image path', file_path)

    # The file path contains unicode characters, cannot use cv2.imread() directly
    file_stream = open(file_path, 'rb')
    bytes_arr = bytearray(file_stream.read())
    numpy_ar = np.asarray(bytes_arr, dtype=np.uint8)
    image = cv2.imdecode(numpy_ar, cv2.IMREAD_UNCHANGED)
    print(image.shape)

    # Convert to RGB
    image = cv2.cvtColor(image, cv2.COLOR_BGR2RGB)
    # Convert the RGB  image to grayscale
    gray = cv2.cvtColor(image, cv2.COLOR_RGB2GRAY)

    # Extract the pre-trained face detector from an xml file
    face_cascade = cv2.CascadeClassifier('detector_architectures/haarcascade_frontalface_default.xml')

    # Detect the faces in image
    faces = face_cascade.detectMultiScale(gray, scaleFactor, minNeighb)

    # Print the number of faces detected in the image
    print('Number of faces detected:', len(faces))

    # Make a copy of the orginal image to draw face detections on
    image_with_detections = np.copy(image)

    # The list of detected faces
    image_faces = []
    # Get the bounding box for each detected face
    for (x,y,w,h) in faces:
        # Add a red bounding box to the detections image
        if w > 200:
            line_width = w//20
        else:
            line_width = 3
        cur_face = image[y:(y+h), x:(x+w)]
        image_faces.append(cur_face)
        cv2.rectangle(image_with_detections, (x,y), (x+w,y+h), (255,0,0), line_width)
        if recognize:
            cur_face = cv2.resize(cur_face, (299,299))
            name = recognize_face(cur_face)

            print('x,y,w,h', x,y,w,h)
            print(name)

            cv2.putText(image_with_detections, name,
                        (x,y-100),cv2.FONT_HERSHEY_SIMPLEX, 7, (255,0,0),20,cv2.LINE_AA)

    if display:
        # Display the image with the detections
        fig = plt.figure(figsize=(15, 15))
        ax = fig.add_subplot(1, 1, 1, xticks=[], yticks=[])
        ax.set_title('Test Image')
        ax.imshow(image_with_detections)
    os.chdir(cur_dir)
```

In [214]:
```
detect_faces('./test_2.jpg', True, True, 1.35, 5)
```

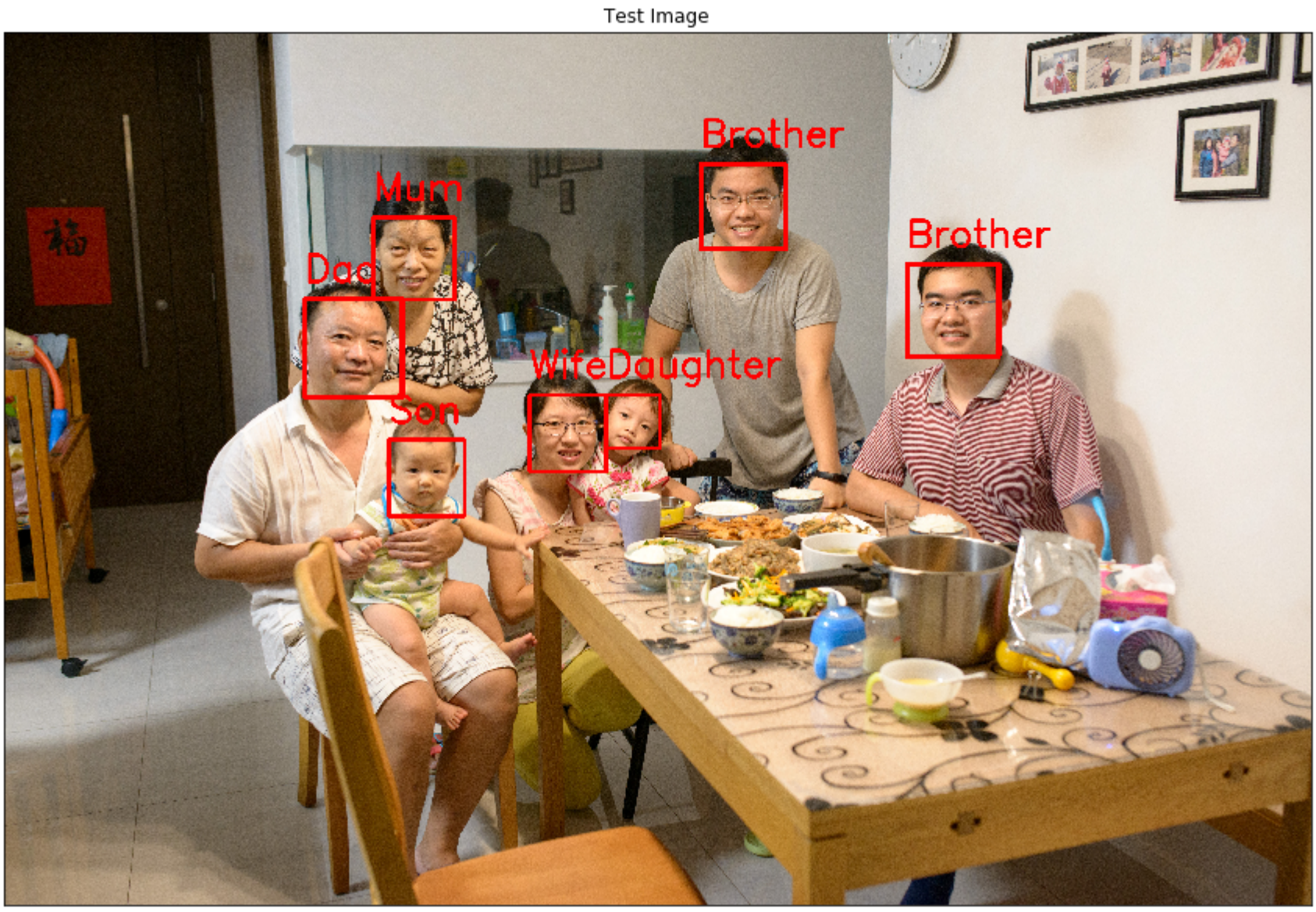
```
Image path ./test_2.jpg
(4766, 7141, 3)
Number of faces detected: 4
x,y,w,h 1997 1163 658 658
Mum
x,y,w,h 2798 1090 546 546
Daughter
x,y,w,h 3805 1292 614 614
Son
x,y,w,h 4285 857 765 765
Dad
```

Test Image



In [212]:
```
detect_faces('./test_1.jpg', True, True, 1.3, 7)
```

```
Image path ./test_1.jpg
(4912, 7360, 3)
Number of faces detected: 7
x,y,w,h 2080 1051 459 459
Mum
x,y,w,h 3923 750 477 477
Brother
x,y,w,h 2961 2047 430 430
Wife
x,y,w,h 1693 1509 550 550
Dad
x,y,w,h 2166 2300 427 427
Son
x,y,w,h 5083 1313 518 518
Brother
x,y,w,h 3392 2045 302 302
Daughter
```



And now I finally have a 'theoretical' evidence that how much I look like my brother. Depite we're not twins, many friends say we look 'exactly' like twins!!!

In [ ]: