```
from keras import backend as K
from keras.models import Sequential
from keras.layers import Activation,Conv2D,MaxPool2D
from keras.layers.core import Dense, Flatten
from keras.optimizers import Adam
from keras.metrics import categorical_crossentropy
from keras.preprocessing.image import ImageDataGenerator
from keras.applications.vgg16 import VGG16
from keras.preprocessing import image
from keras.applications.vgg16 import preprocess_input,
decode_predictions
from sklearn.model_selection import train_test_split
from sklearn.metrics import confusion_matrix
import numpy as np
from keras.utils import to_categorical
from PIL import Image
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense, Dropout,
GlobalAveragePooling2D
import matplotlib.pyplot as plt
import glob,cv2,os
import itertools
import keras
import itertools
%matplotlib inline
```

```
VGG_model = keras.applications.VGG16(weights='imagenet',
include_top=False,input_shape=(224, 224, 3))
print('VGG16',len(VGG_model.layers))
```

```
VGG16 19
```

```
x_real = np.load('dataset_c/x_real.npz')['data']
y_real = np.load('dataset_c/y_real.npy')
x_easy = np.load('dataset_c/x_easy.npz')['data']
y_easy = np.load('dataset_c/y_easy.npy')
x_medium = np.load('dataset_c/x_medium.npz')['data']
y_medium = np.load('dataset_c/y_medium.npy')
x_hard = np.load('dataset_c/x_hard.npz')['data']
y_hard = np.load('dataset_c/y_hard.npy')
```

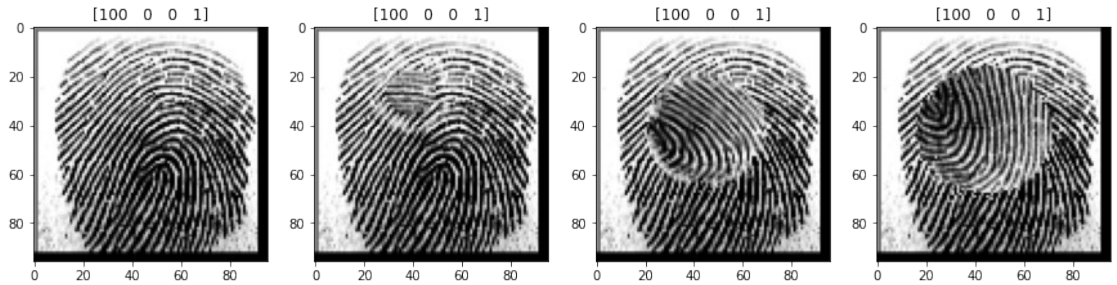
```
print(x_real.shape, y_real.shape)
```

```
plt.figure(figsize=(15, 10))
plt.subplot(1, 4, 1)
plt.title(y_real[0])
plt.imshow(x_real[0].squeeze()) # cmap='gray'
plt.subplot(1, 4, 2)
plt.title(y_easy[0])
plt.imshow(x_easy[0].squeeze())
plt.subplot(1, 4, 3)
plt.title(y_medium[0])
plt.imshow(x_medium[0].squeeze())
plt.subplot(1, 4, 4)
plt.title(y_hard[0])
plt.imshow(x_hard[0].squeeze())
```

```
(6000, 96, 96, 3) (6000, 4)
```

```
C:\Users\USER\anaconda3\lib\site-packages\matplotlib\text.py:1223:
FutureWarning: elementwise comparison failed; returning scalar
instead, but in the future will perform elementwise comparison
  if s != self._text:
```

```
<matplotlib.image.AxesImage at 0x2b858b4c910>
```



```
print(x_real.shape)
print(y_real.shape)
print(x_easy.shape)
print(y_easy.shape)
print(x_medium.shape)
print(y_medium.shape)
print(x_hard.shape)
print(y_hard.shape)
```

```
(6000, 96, 96, 3)
(6000, 4)
(17931, 96, 96, 3)
(17931, 4)
(17067, 96, 96, 3)
(17067, 4)
(14272, 96, 96, 3)
(14272, 4)
```

```
x_all_data = np.concatenate([x_easy, x_medium, x_hard], axis=0)
label_all_data = np.concatenate([y_easy, y_medium, y_hard], axis=0)
print(x_all_data.shape, label_all_data.shape)

permutation = list(np.random.permutation(x_all_data.shape[0])) # permutation 隨機排列
x_data = x_all_data[permutation][:6000]
label_data = label_all_data[permutation][:6000]
```

```
x_train, x_val, label_train, label_val = train_test_split(x_data,
label_data, test_size=0.2)

print(x_data.shape, label_data.shape) #
print(x_train.shape, label_train.shape) # 訓練
print(x_val.shape, label_val.shape) # 驗證
```

```
(49270, 96, 96, 3) (49270, 4)
(6000, 96, 96, 3) (6000, 4)
(4800, 96, 96, 3) (4800, 4)
(1200, 96, 96, 3) (1200, 4)
```

```
permutation = list(np.random.permutation(x_real.shape[0])) #
permutation 隨機排列
x_test = x_real[permutation][:1200]
label_test = y_real[permutation][:1200]

print(x_test.shape, label_test.shape) # 測試
```

```
(1200, 96, 96, 3) (1200, 4)
```

```
# 調整 X_train 的圖片尺寸
print('調整 X_train 的圖片尺寸...')
X_train_new = np.array(
    [np.asarray(Image.fromarray(x_train[i]).resize(
        (224, 224))) for i in range(0, len(x_train))])
X_train_new = X_train_new.astype('float32')
```

```
調整 X_train 的圖片尺寸...
```

```
X_train_new.shape
```

```
(4800, 224, 224, 3)
```

```
# 訓練資料的資料前處理
train_input = preprocess_input(X_train_new)
# 使用 VGG16 模型預測訓練資料的特徵資料
print('使用 VGG16 模型預測訓練資料的特徵資料...')
train_features = VGG_model.predict(train_input, verbose=1)
```

```
使用 VGG16 模型預測訓練資料的特徵資料...
150/150 [==============================] - 740s 5s/step
```

```
train_features.shape
```

```
(4800, 7, 7, 512)
```

```
# 調整 X_val 的圖片尺寸
print('調整 X_val 的圖片尺寸...')
X_val_new = np.array(
    [np.asarray(Image.fromarray(x_val[i]).resize(
        (224, 224))) for i in range(0, len(x_val))])
X_val_new = X_val_new.astype('float32')
```

```
調整 X_val 的圖片尺寸...
```

```
X_val_new.shape
```

```
(1200, 224, 224, 3)
```

```
# 驗證資料的資料前處理
val_input = preprocess_input(X_val_new)
# 使用 VGG16 模型預測驗證資料的特徵資料
print('使用 VGG16 模型預測驗證資料的特徵資料...')
val_features = VGG_model.predict(val_input, verbose=1)
```

```
使用 VGG16 模型預測驗證資料的特徵資料...
38/38 [==============================] - 178s 5s/step
```

```
val_features.shape
```

```
(1200, 7, 7, 512)
```

```
# 調整 X_test 的圖片尺寸
print('調整 X_test 的圖片尺寸...')
X_test_new = np.array(
    [np.asarray(Image.fromarray(x_test[i]).resize(
        (224, 224))) for i in range(0, len(x_test))])
X_test_new = X_test_new.astype('float32')
```

```
調整 X_test 的圖片尺寸...
```

```
X_test_new.shape
```

```
(1200, 224, 224, 3)
```

```
# 測試資料的資料前處理
test_input = preprocess_input(X_test_new)
# 使用 VGG16 模型預測測試資料的特徵資料
print('使用 VGG16 模型預測測試資料的特徵資料...')
test_features = VGG_model.predict(test_input, verbose=1)
```

```
使用 VGG16 模型預測測試資料的特徵資料...
38/38 [==============================] - 178s 5s/step
```

```
test_features.shape
```

```
(1200, 7, 7, 512)
```

```
print('訓練：')
id_label_train = to_categorical(label_train[:,0]-1) # 減 1 是因為 id 為 1~600
print('身分',id_label_train.shape)
gender_label_train = to_categorical(label_train[:,1])
```

```
print('性別',gender_label_train.shape)
lr_label_train = to_categorical(label_train[:,2])
print('左右',lr_label_train.shape)
finger_label_train = to_categorical(label_train[:,3])
print('指頭',finger_label_train.shape)

print('驗證：')
id_label_val = to_categorical(label_val[:,0]-1)
print('身分',id_label_val.shape)
gender_label_val = to_categorical(label_val[:,1])
print('性別',gender_label_val.shape)
lr_label_val = to_categorical(label_val[:,2])
print('左右',lr_label_val.shape)
finger_label_val = to_categorical(label_val[:,3])
print('指頭',finger_label_val.shape)

print('測試：')
id_label_test = to_categorical(label_test[:,0]-1)
print('身分',id_label_test.shape)
gender_label_test = to_categorical(label_test[:,1])
print('性別',gender_label_test.shape)
lr_label_test = to_categorical(label_test[:,2])
print('左右',lr_label_test.shape)
finger_label_test = to_categorical(label_test[:,3])
print('指頭',finger_label_test.shape)
```

```
訓練：
身分 (4800, 600)
性別 (4800, 2)
左右 (4800, 2)
指頭 (4800, 5)
驗證：
身分 (1200, 600)
性別 (1200, 2)
左右 (1200, 2)
指頭 (1200, 5)
測試：
身分 (1200, 600)
性別 (1200, 2)
左右 (1200, 2)
指頭 (1200, 5)
```

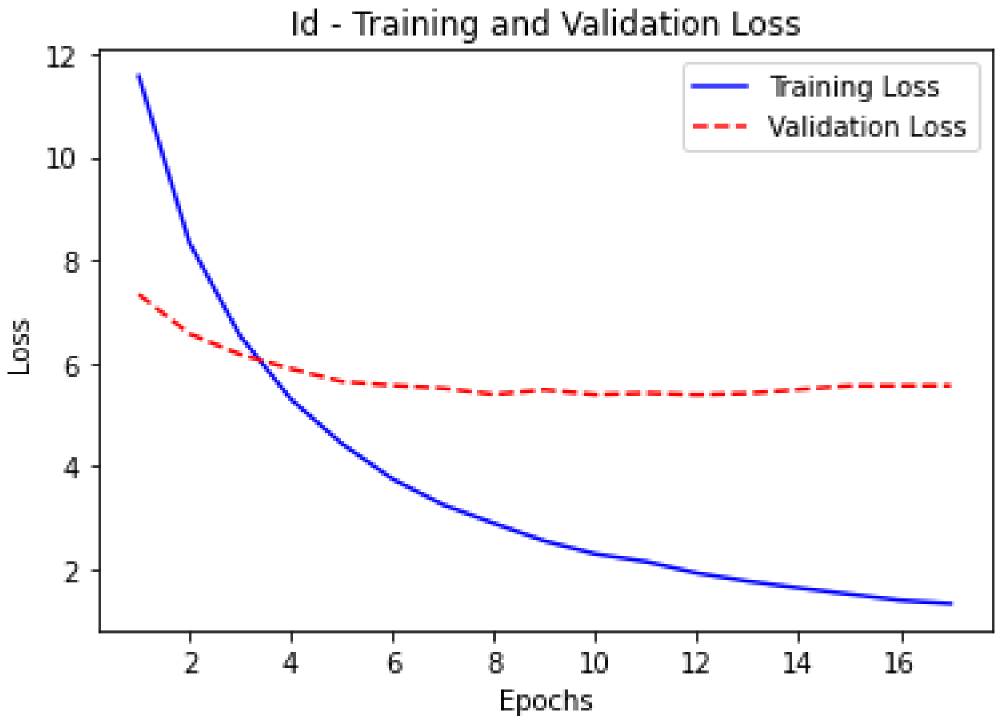
```
from keras.callbacks import EarlyStopping
# 建立EarlyStopping 物件
es = EarlyStopping(monitor='val_loss', mode='min',
                   verbose=1, patience=5)

from keras.callbacks import ModelCheckpoint
# 建立ModelCheckpoint 物件
filename = './data/id_weights.h5'
```

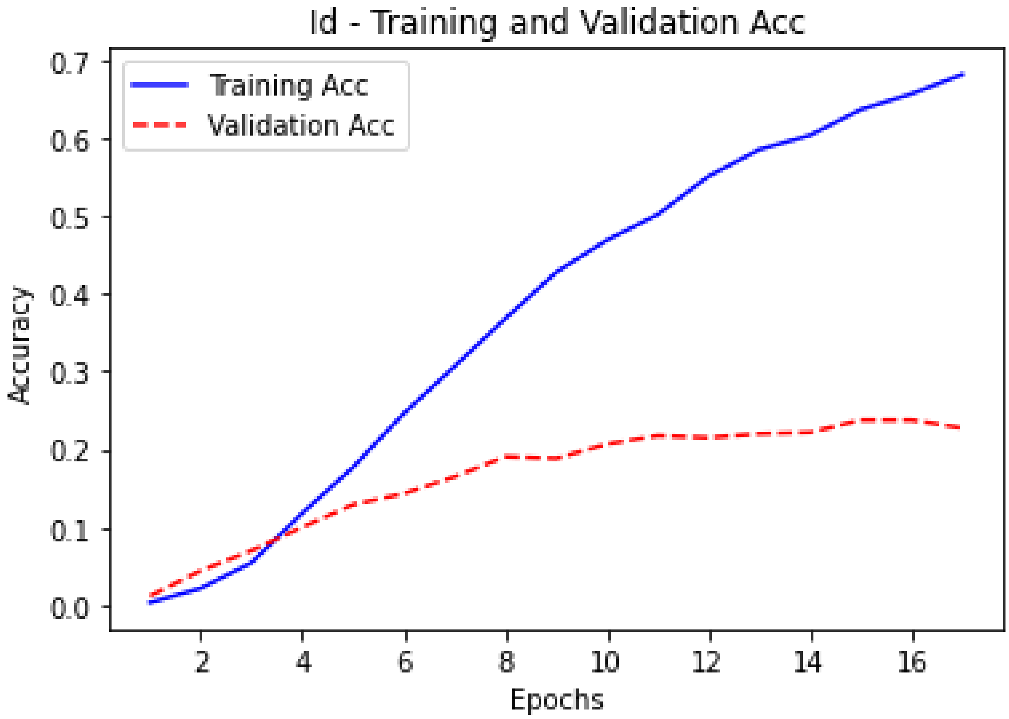
```
mc = ModelCheckpoint(filename, monitor='val_accuracy',
                     mode='max', verbose=0,
                     save_best_only=True)

# 定義模型
model = Sequential()
model.add(GlobalAveragePooling2D(
         input_shape=train_features.shape[1:]))
model.add(Dropout(0.5))
model.add(Dense(600, activation='softmax'))

# 編譯模型
model.compile(loss='categorical_crossentropy', optimizer='adam',
             metrics=['accuracy'])
# 訓練模型
# validation_split：0~1 之間的浮點數，用來指定訓練集的一定比例數據作為驗證集。
# validation_data：形式為（X，y）或（X，y，sample_weights）的 tuple，是指定的
驗證集。
history = model.fit(train_features, id_label_train,
                    validation_data=(val_features, id_label_val),
                    epochs=100, batch_size=32, verbose=0,
                    callbacks=[es, mc])
# 評估模型
print('\nTesting ...')
loss, accuracy = model.evaluate(test_features, id_label_test,
verbose=1)
print('測試資料集的準確度 = {:.2f}'.format(accuracy))
```

```
Epoch 17: early stopping

Testing ...
38/38 [==============================] - 0s 4ms/step - loss: 3.8135 -
accuracy: 0.3892
測試資料集的準確度 = 0.39
```

```
import matplotlib.pyplot as plt
%matplotlib inline

# 顯示訓練和驗證損失
loss = history.history['loss']
epochs = range(1, len(loss) + 1)
val_loss = history.history['val_loss']
plt.plot(epochs, loss, 'b-', label='Training Loss')
plt.plot(epochs, val_loss, 'r--', label='Validation Loss')
plt.title('Id - Training and Validation Loss')
plt.xlabel('Epochs')
plt.ylabel('Loss')
plt.legend()
plt.show()
# 顯示訓練和驗證準確度 注意 accyracy  要改成 acc，val_accuracy => val_acc，因為
```

```
keras 版本問題
acc = history.history['accuracy']
epochs = range(1, len(acc) + 1)
val_acc = history.history['val_accuracy']
plt.plot(epochs, acc, 'b-', label='Training Acc')
plt.plot(epochs, val_acc, 'r--', label='Validation Acc')
plt.title('Id - Training and Validation Acc')
plt.xlabel('Epochs')
plt.ylabel('Accuracy')
plt.legend()
plt.show()
```



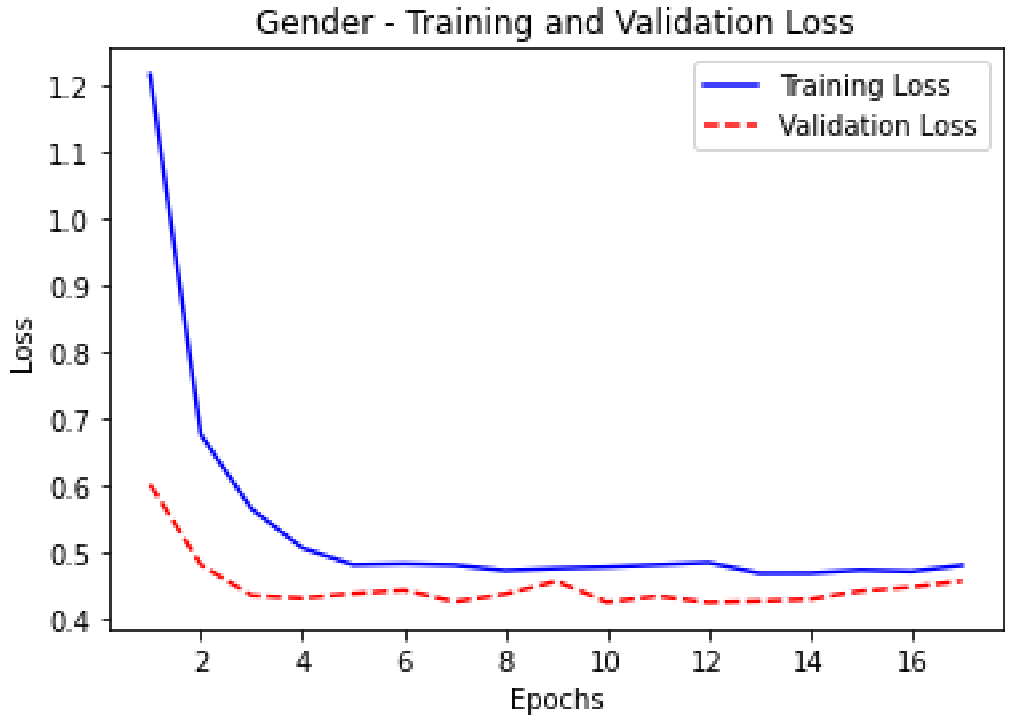


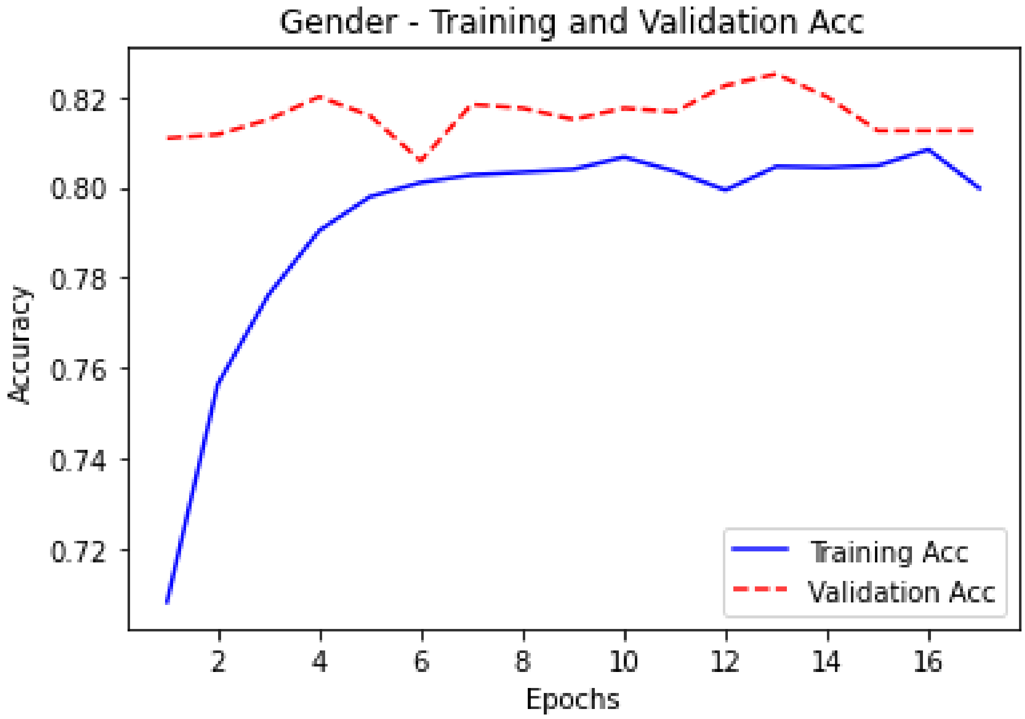
```
from keras.callbacks import EarlyStopping
# 建立EarlyStopping 物件
es = EarlyStopping(monitor='val_loss', mode='min',
                   verbose=1, patience=5)

from keras.callbacks import ModelCheckpoint
# 建立ModelCheckpoint 物件
filename = './data/id_weights.h5'
mc = ModelCheckpoint(filename, monitor='val_accuracy',
                     mode='max', verbose=0,
                     save_best_only=True)

# 定義模型
model = Sequential()
model.add(GlobalAveragePooling2D(
         input_shape=train_features.shape[1:]))
model.add(Dropout(0.5))
model.add(Dense(2, activation='softmax'))

# 編譯模型
model.compile(loss='categorical_crossentropy', optimizer='adam',
             metrics=['accuracy'])
# 訓練模型
# validation_split：0~1 之間的浮點數，用來指定訓練集的一定比例數據作為驗證集。
# validation_data：形式為（X，y）或（X，y，sample_weights）的 tuple，是指定的
驗證集。
history = model.fit(train_features, gender_label_train,
                    validation_data=(val_features, gender_label_val),
                    epochs=100, batch_size=32, verbose=0,
                    callbacks=[es, mc])
# 評估模型
print('\nTesting ...')
loss, accuracy = model.evaluate(test_features, gender_label_test,
verbose=1)
print('測試資料集的準確度= {:.2f}'.format(accuracy))
```

```
Epoch 17: early stopping

Testing ...
38/38 [==============================] - 0s 3ms/step - loss: 0.5187 -
accuracy: 0.7875
測試資料集的準確度= 0.79
```

```
import matplotlib.pyplot as plt
%matplotlib inline
```

```
# 顯示訓練和驗證損失
loss = history.history['loss']
epochs = range(1, len(loss) + 1)
val_loss = history.history['val_loss']
plt.plot(epochs, loss, 'b-', label='Training Loss')
plt.plot(epochs, val_loss, 'r--', label='Validation Loss')
plt.title('Gender - Training and Validation Loss')
plt.xlabel('Epochs')
plt.ylabel('Loss')
plt.legend()
plt.show()
# 顯示訓練和驗證準確度 注意 accyracy  要改成 acc , val_accuracy => val_acc , 因為
keras 版本問題
acc = history.history['accuracy']
epochs = range(1, len(acc) + 1)
val_acc = history.history['val_accuracy']
plt.plot(epochs, acc, 'b-', label='Training Acc')
plt.plot(epochs, val_acc, 'r--', label='Validation Acc')
plt.title('Gender - Training and Validation Acc')
plt.xlabel('Epochs')
plt.ylabel('Accuracy')
plt.legend()
plt.show()
```



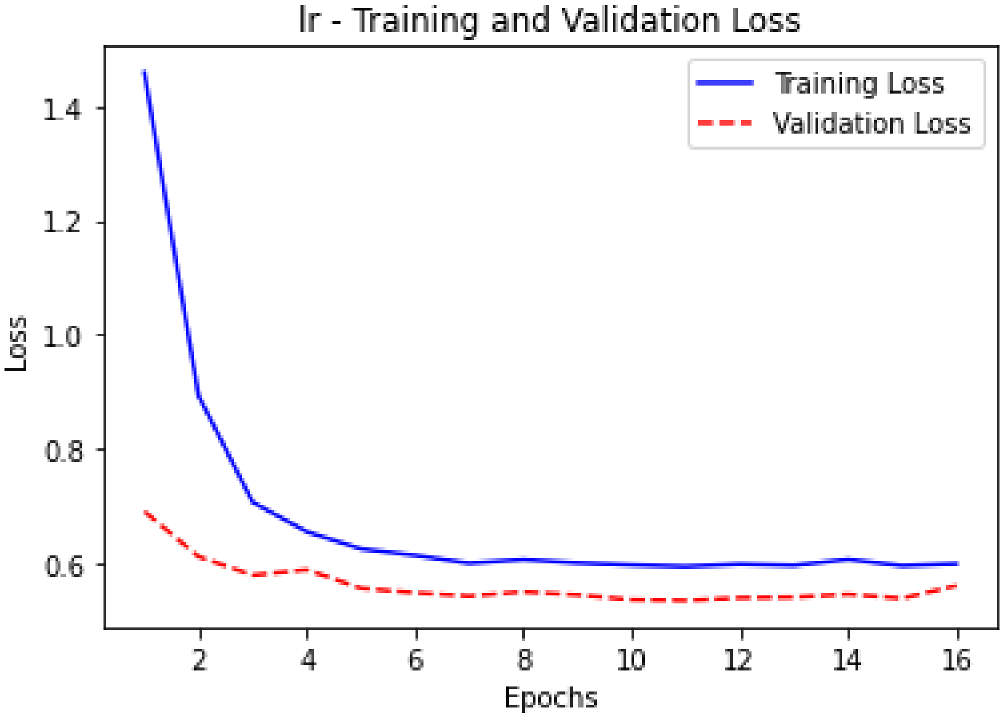


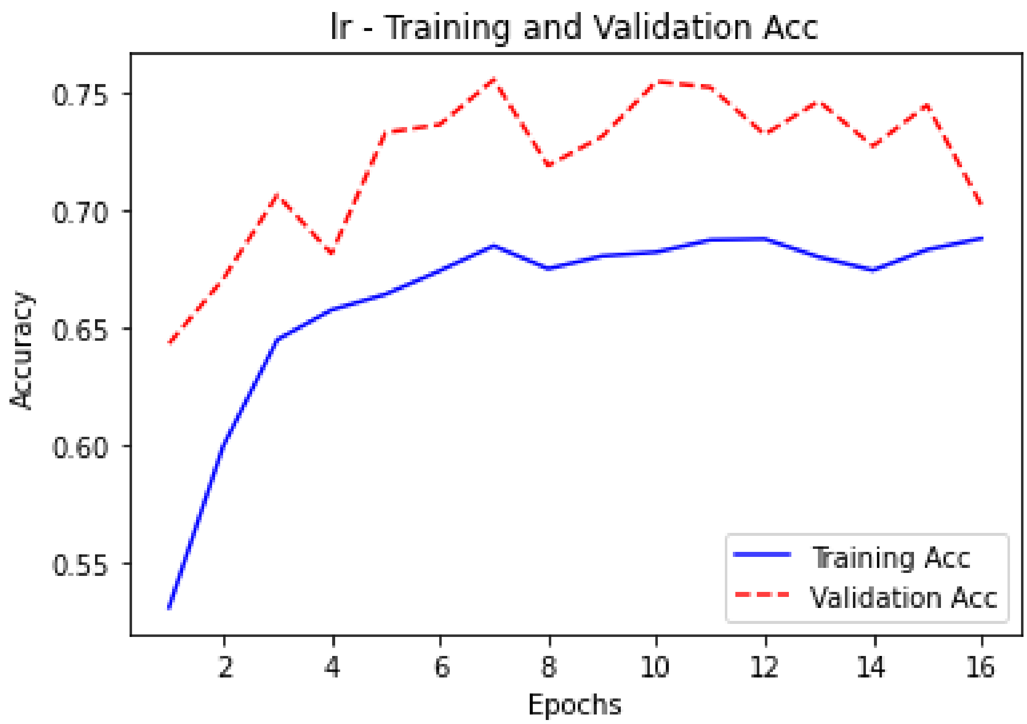
```
from keras.callbacks import EarlyStopping
# 建立EarlyStopping 物件
es = EarlyStopping(monitor='val_loss', mode='min',
                   verbose=1, patience=5)
```

```
from keras.callbacks import ModelCheckpoint
# 建立ModelCheckpoint 物件
filename = './data/lr_weights.h5'
mc = ModelCheckpoint(filename, monitor='val_accuracy',
                     mode='max', verbose=0,
                     save_best_only=True)

# 定義模型
model = Sequential()
model.add(GlobalAveragePooling2D(
         input_shape=train_features.shape[1:]))
model.add(Dropout(0.5))
model.add(Dense(2, activation='softmax'))

# 編譯模型
model.compile(loss='binary_crossentropy', optimizer='adam',
              metrics=['accuracy'])
# 訓練模型
# validation_split：0~1之間的浮點數，用來指定訓練集的一定比例數據作為驗證集。
# validation_data：形式為（X，y）或（X，y，sample_weights）的tuple，是指定的
驗證集。
history = model.fit(train_features, lr_label_train,
                    validation_data=(val_features, lr_label_val),
                    epochs=100, batch_size=32, verbose=0,
                    callbacks=[es, mc])
# 評估模型
print('\nTesting ...')
loss, accuracy = model.evaluate(test_features, lr_label_test,
verbose=1)
print('測試資料集的準確度 = {:.2f}'.format(accuracy))
```

```
Epoch 16: early stopping

Testing ...
38/38 [==============================] - 0s 3ms/step - loss: 0.5460 -
accuracy: 0.7267
測試資料集的準確度 = 0.73
```

```
import matplotlib.pyplot as plt
%matplotlib inline

# 顯示訓練和驗證損失
loss = history.history['loss']
epochs = range(1, len(loss) + 1)
val_loss = history.history['val_loss']
plt.plot(epochs, loss, 'b-', label='Training Loss')
plt.plot(epochs, val_loss, 'r--', label='Validation Loss')
plt.title('lr - Training and Validation Loss')
plt.xlabel('Epochs')
plt.ylabel('Loss')
plt.legend()
plt.show()
# 顯示訓練和驗證準確度 注意 accyracy  要改成 acc , val_accuracy => val_acc , 因為 keras 版本問題
acc = history.history['accuracy']
epochs = range(1, len(acc) + 1)
val_acc = history.history['val_accuracy']
plt.plot(epochs, acc, 'b-', label='Training Acc')
plt.plot(epochs, val_acc, 'r--', label='Validation Acc')
plt.title('lr - Training and Validation Acc')
plt.xlabel('Epochs')
plt.ylabel('Accuracy')
plt.legend()
plt.show()
```

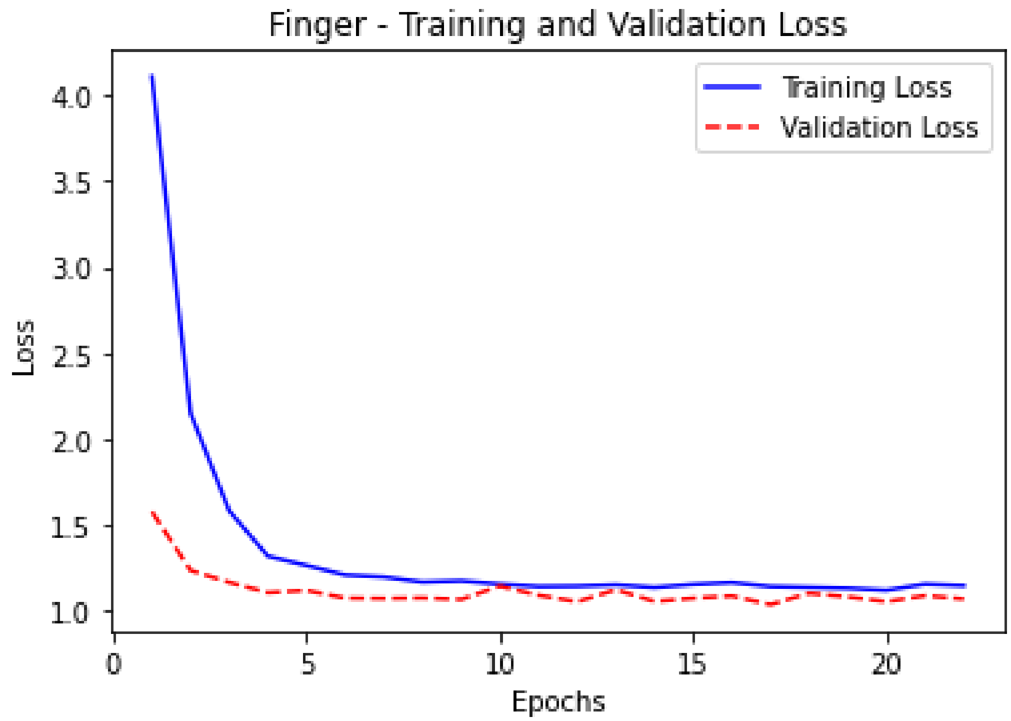


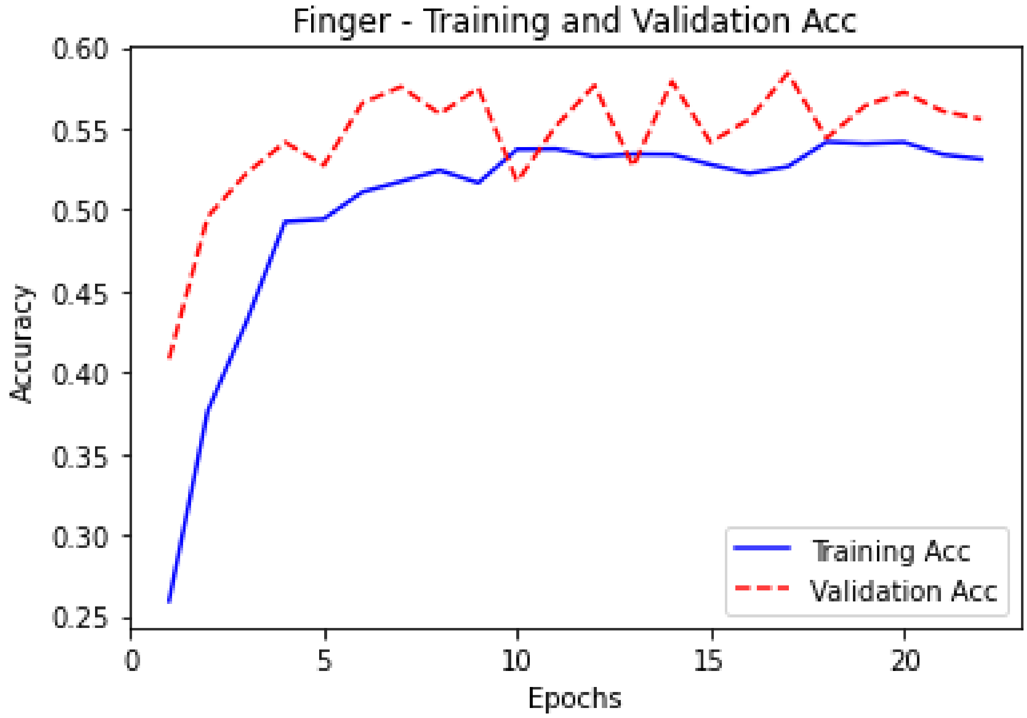


```
from keras.callbacks import EarlyStopping
# 建立EarlyStopping 物件
es = EarlyStopping(monitor='val_loss', mode='min',
                   verbose=1, patience=5)

from keras.callbacks import ModelCheckpoint
# 建立ModelCheckpoint 物件
filename = './data/id_weights.h5'
mc = ModelCheckpoint(filename, monitor='val_accuracy',
                     mode='max', verbose=0,
                     save_best_only=True)

# 定義模型
model = Sequential()
model.add(GlobalAveragePooling2D(
         input_shape=train_features.shape[1:]))
model.add(Dropout(0.5))
model.add(Dense(5, activation='softmax'))

# 編譯模型
model.compile(loss='categorical_crossentropy', optimizer='adam',
              metrics=['accuracy'])
# 訓練模型
# validation_split：0~1之間的浮點數，用來指定訓練集的一定比例數據作為驗證集。
# validation_data：形式為（X，y）或（X，y，sample_weights）的tuple，是指定的
驗證集。
history = model.fit(train_features, finger_label_train,
                    validation_data=(val_features, finger_label_val),
                    epochs=100, batch_size=32, verbose=0,
                    callbacks=[es, mc])
# 評估模型
print('\nTesting ...')
loss, accuracy = model.evaluate(test_features, finger_label_test,
verbose=1)
print('測試資料集的準確度= {:.2f}'.format(accuracy))
```

```
Epoch 22: early stopping

Testing ...
38/38 [==============================] - 0s 3ms/step - loss: 0.9924 -
accuracy: 0.6133
測試資料集的準確度= 0.61
```

```
import matplotlib.pyplot as plt
%matplotlib inline

# 顯示訓練和驗證損失
loss = history.history['loss']
epochs = range(1, len(loss) + 1)
val_loss = history.history['val_loss']
plt.plot(epochs, loss, 'b-', label='Training Loss')
plt.plot(epochs, val_loss, 'r--', label='Validation Loss')
plt.title('Finger - Training and Validation Loss')
plt.xlabel('Epochs')
plt.ylabel('Loss')
plt.legend()
plt.show()
# 顯示訓練和驗證準確度 注意 accyracy 要改成 acc , val_accuracy => val_acc , 因為
keras 版本問題
acc = history.history['accuracy']
epochs = range(1, len(acc) + 1)
val_acc = history.history['val_accuracy']
plt.plot(epochs, acc, 'b-', label='Training Acc')
plt.plot(epochs, val_acc, 'r--', label='Validation Acc')
plt.title('Finger - Training and Validation Acc')
plt.xlabel('Epochs')
plt.ylabel('Accuracy')
plt.legend()
plt.show()
```


Finger - Training and Validation Loss
Training Loss
Validation Loss
Loss
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0
5
10
15
20
Epochs


Finger - Training and Validation Acc
Training Acc
Validation Acc
Accuracy
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0
5
10
15
20
Epochs