

Personal Project_04_v10_test1_4conv-layer

April 28, 2025

```
[1]: import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
%matplotlib inline
import matplotlib.image as mpimg
import tensorflow as tf
```

```
[2]: # default initial values of DOE factors:
# learning_rate = 0.001
# dropout_value = 0.3
# #n-conv_layers = 3
# n_units_last_layer = 2048
# n_filters_l1 = 32
# n_filters_l2 = 16
```

```
[3]: # DOE factors:
learning_rate = 0.005
dropout_value = 0.2
# n-conv_layers = 4
n_units_last_layer = 1024
n_filters_l1 = 32
n_filters_l2 = 64
```

```
[4]: # other factors:
img_size = 130
batch_size = 32
validation_split = 0.1 # 10% for validation
test_split = 0.00 # 0% for testing
shuffle_buffer_size = 1000
seed_num = 101
desired_accuracy = 0.99 # it should be active if EarlyStoppingCallback is
↳activated
loss = 'binary_crossentropy'
#optimizer = tf.keras.optimizers.RMSprop(learning_rate=learning_rate)
optimizer = tf.keras.optimizers.Adam(learning_rate=learning_rate)
metrics = ['accuracy']
epochs = 15
f_mode = 'nearest' # fill_mode in image augmentation
```

```

My dataset_root/
  woman/
    woman_1.jpg
    woman_2.jpg
    ...
  man/
    man_1.jpg
    man_2.jpg
    ...

```

```

[6]: import os

DATA_DIR = "D:\\CS online courses\\Free DataSets\\Free Images\\Easier portrait_
↳images_GPU_03"

# Subdirectories for each class
data_dir_woman = os.path.join(DATA_DIR, 'woman')
data_dir_man = os.path.join(DATA_DIR, 'man')

# os.listdir returns a list containing all files under the given dir
print(f"There are {len(os.listdir(data_dir_woman))} images of woman.")
print(f"There are {len(os.listdir(data_dir_man))} images of man.")

```

There are 471 images of woman.

There are 472 images of man.

```

[7]: image_size = (img_size, img_size) # Resize images to this size

# Load train dataset (excluding validation & test set):
train_dataset = tf.keras.utils.image_dataset_from_directory(
    directory = DATA_DIR,
    image_size = image_size,
    batch_size = batch_size,
    label_mode='binary',
    validation_split = validation_split + test_split, # Total split for val +
↳test
    subset = "training",
    seed = seed_num
)

# Load validation dataset
val_dataset = tf.keras.utils.image_dataset_from_directory(
    directory = DATA_DIR,
    image_size = image_size,
    batch_size = batch_size,
    label_mode='binary',
    validation_split = validation_split + test_split,
    subset = "validation",

```

```

        seed = seed_num
    )

    # Further manually split validation dataset to extract test dataset
    val_batches = tf.data.experimental.cardinality(val_dataset)
    # Compute test dataset size (number of batches)
    test_size = round(val_batches.numpy() * (test_split / (validation_split +
        ↪test_split)))
    # Split validation dataset into validation and test subsets
    test_dataset = val_dataset.take(test_size)
    val_dataset = val_dataset.skip(test_size)

    print(f"Train batches: {tf.data.experimental.cardinality(train_dataset).
        ↪numpy()}")
    print(f"Validation batches: {tf.data.experimental.cardinality(val_dataset).
        ↪numpy()}")
    print(f"Test batches: {tf.data.experimental.cardinality(test_dataset).numpy()}")

    # Optimize for performance
    AUTOTUNE = tf.data.AUTOTUNE
    training_dataset = train_dataset.cache().shuffle(shuffle_buffer_size).
        ↪prefetch(buffer_size = AUTOTUNE)
    validation_dataset = val_dataset.cache().prefetch(buffer_size = AUTOTUNE)
    test_dataset = test_dataset.cache().prefetch(buffer_size = AUTOTUNE)

```

```

Found 943 files belonging to 2 classes.
Using 849 files for training.
Found 943 files belonging to 2 classes.
Using 94 files for validation.
Train batches: 27
Validation batches: 3
Test batches: 0

```

```

[8]: # Get the first batch of images and labels
for images, labels in training_dataset.take(1):
    example_batch_images = images
    example_batch_labels = labels

max_pixel = np.max(example_batch_images)
print(f"Maximum pixel value of images: {max_pixel}\n")
print(f"Shape of batch of images: {example_batch_images.shape}")
print(f"Shape of batch of labels: {example_batch_labels.shape}")

```

```

Maximum pixel value of images: 255.0

```

```

Shape of batch of images: (32, 130, 130, 3)
Shape of batch of labels: (32, 1)

```

```
[9]: '''
class EarlyStoppingCallback(tf.keras.callbacks.Callback):
    def on_epoch_end(self, epoch, logs=None):
        train_accuracy = logs.get('accuracy')
        val_accuracy = logs.get('val_accuracy')
        if train_accuracy >= desired_accuracy and val_accuracy >=
↳desired_accuracy:
            self.model.stop_training = True
            print(f"\nReached {desired_accuracy}% accuracy so cancelling
↳training!")
'''
```

```
[9]: '\n\nclass EarlyStoppingCallback(tf.keras.callbacks.Callback):\n    def
on_epoch_end(self, epoch, logs=None):\n        train_accuracy =
logs.get(\'accuracy\')\n        val_accuracy = logs.get(\'val_accuracy\')\n
if train_accuracy >= desired_accuracy and val_accuracy >= desired_accuracy:\n
self.model.stop_training = True\n        print(f"\nReached
{desired_accuracy}% accuracy so cancelling training!")\n'
```

```
[10]: '''
from tensorflow.keras.callbacks import EarlyStopping
early_stop = EarlyStopping(monitor='val_loss', patience=3)
'''
```

```
[10]: "\nfrom tensorflow.keras.callbacks import EarlyStopping\nearly_stop =
EarlyStopping(monitor='val_loss', patience=3)\n"
```

```
[11]: from tensorflow.keras.callbacks import LearningRateScheduler

# Reduce LR every 10 epochs (Learning rate decay factor)
def scheduler(epoch, lr):
    if epoch % 10 == 0 and epoch > 0:
        return lr * 1.0
    return lr

lr_callback = LearningRateScheduler(scheduler)
```

```
[12]: # augmentation_model
def augment_model():
    """Creates a model (layers stacked on top of each other) for augmenting
↳images of woman and man.

    Returns:
        tf.keras.Model: The model made up of the layers that will be used to
↳augment the images of woman and man.
    """
```

```

augmentation_model = tf.keras.Sequential([
    # Specify the input shape.
    tf.keras.Input(shape = (img_size, img_size, 3)),

    tf.keras.layers.RandomFlip("horizontal"),
    tf.keras.layers.RandomRotation(0.1, fill_mode = f_mode),
    #tf.keras.layers.RandomTranslation(0.1, 0.1, fill_mode = f_mode),
    #tf.keras.layers.RandomZoom(0.1, fill_mode=f_mode)
])

return augmentation_model

```

```

[13]: def create_and_compile_model():
    """Creates, compiles and trains the model to predict woman and man images.

    Returns:
    tf.keras.Model: The model that will be trained to predict woman and man
    images.
    """

    augmentation_layers = augment_model()

    model = tf.keras.Sequential([
        # Note: the input shape is the desired size of the image: 150x150 with
        3 bytes for color
        tf.keras.layers.InputLayer(shape = (img_size, img_size, 3)),
        augmentation_layers,
        tf.keras.layers.Rescaling(1./255),
        ##### CONV_LAYER_1: #####
        tf.keras.layers.Conv2D(n_filters_l1, (4, 4), activation = 'linear'),
        tf.keras.layers.MaxPooling2D(2, 2),
        ##### CONV_LAYER_2: #####
        tf.keras.layers.Conv2D(n_filters_l2, (3, 3), activation = 'relu'),
        tf.keras.layers.MaxPooling2D(2, 2),
        ##### CONV_LAYER_3: #####
        tf.keras.layers.Conv2D(64, (3, 3), activation = 'relu'),
        tf.keras.layers.MaxPooling2D(2, 2),
        ##### CONV_LAYER_4: #####
        tf.keras.layers.Conv2D(64, (3, 3), activation = 'relu'),
        tf.keras.layers.MaxPooling2D(2, 2),
        tf.keras.layers.Flatten(),
        tf.keras.layers.Dropout(dropout_value),
        ##### BEFORE_LAST_LAYER: #####
        tf.keras.layers.Dense(n_units_last_layer, activation = 'relu'),
        # It will contain a value from 0-1 where 0 for the class 'female' and 1
        for the 'male'
        tf.keras.layers.Dense(1, activation = 'sigmoid')])

```

```

model.compile(
    loss = loss,
    optimizer = optimizer,
    metrics = metrics
)

return model

```

```

[14]: # Create the compiled but untrained model
model = create_and_compile_model()
model.summary()

```

Model: "sequential_1"

| Layer (type) | Output Shape | Param # |
|--------------------------------|----------------------|-----------|
| sequential (Sequential) | (None, 130, 130, 3) | 0 |
| rescaling (Rescaling) | (None, 130, 130, 3) | 0 |
| conv2d (Conv2D) | (None, 127, 127, 32) | 1,568 |
| max_pooling2d (MaxPooling2D) | (None, 63, 63, 32) | 0 |
| conv2d_1 (Conv2D) | (None, 61, 61, 64) | 18,496 |
| max_pooling2d_1 (MaxPooling2D) | (None, 30, 30, 64) | 0 |
| conv2d_2 (Conv2D) | (None, 28, 28, 64) | 36,928 |
| max_pooling2d_2 (MaxPooling2D) | (None, 14, 14, 64) | 0 |
| conv2d_3 (Conv2D) | (None, 12, 12, 64) | 36,928 |
| max_pooling2d_3 (MaxPooling2D) | (None, 6, 6, 64) | 0 |
| flatten (Flatten) | (None, 2304) | 0 |
| dropout (Dropout) | (None, 2304) | 0 |
| dense (Dense) | (None, 1024) | 2,360,320 |
| dense_1 (Dense) | (None, 1) | 1,025 |

Total params: 2,455,265 (9.37 MB)

Trainable params: 2,455,265 (9.37 MB)

Non-trainable params: 0 (0.00 B)

```
[15]: '''  
      training_history = model.fit(  
          training_dataset,  
          epochs = epochs,  
          validation_data = validation_dataset,  
          callbacks = [EarlyStoppingCallback()],  
          verbose = 2  
      )  
      '''
```

```
[15]: '\ntraining_history = model.fit(\n    training_dataset,\n    epochs = epochs,\n    validation_data = validation_dataset,\n    callbacks =  
    [EarlyStoppingCallback()],\n    verbose = 2\n)\n'
```

```
[16]: '''  
      training_history = model.fit(  
          training_dataset,  
          epochs = epochs,  
          validation_data = validation_dataset,  
          callbacks=[early_stop],  
          verbose = 2  
      )  
      '''
```

```
[16]: '\ntraining_history = model.fit(\n    training_dataset,\n    epochs = epochs,\n    validation_data = validation_dataset,\n    callbacks=[early_stop],\n    verbose = 2\n)\n'
```

```
[17]: training_history = model.fit(  
      training_dataset,  
      epochs = epochs,  
      validation_data = validation_dataset,  
      callbacks = [lr_callback],  
      verbose = 2  
  )
```

Epoch 1/15

27/27 - 4s - 164ms/step - accuracy: 0.5465 - loss: 1.2888 - val_accuracy: 0.5851
- val_loss: 0.6719 - learning_rate: 0.0050

Epoch 2/15

```

27/27 - 3s - 96ms/step - accuracy: 0.6443 - loss: 0.6468 - val_accuracy: 0.6170
- val_loss: 0.6685 - learning_rate: 0.0050
Epoch 3/15
27/27 - 3s - 94ms/step - accuracy: 0.6313 - loss: 0.6405 - val_accuracy: 0.6277
- val_loss: 0.6514 - learning_rate: 0.0050
Epoch 4/15
27/27 - 3s - 93ms/step - accuracy: 0.6525 - loss: 0.6279 - val_accuracy: 0.5957
- val_loss: 0.6800 - learning_rate: 0.0050
Epoch 5/15
27/27 - 3s - 98ms/step - accuracy: 0.6843 - loss: 0.5913 - val_accuracy: 0.6170
- val_loss: 0.6154 - learning_rate: 0.0050
Epoch 6/15
27/27 - 3s - 98ms/step - accuracy: 0.6631 - loss: 0.6042 - val_accuracy: 0.6809
- val_loss: 0.6416 - learning_rate: 0.0050
Epoch 7/15
27/27 - 3s - 94ms/step - accuracy: 0.6938 - loss: 0.5806 - val_accuracy: 0.6170
- val_loss: 0.6397 - learning_rate: 0.0050
Epoch 8/15
27/27 - 3s - 93ms/step - accuracy: 0.6902 - loss: 0.5785 - val_accuracy: 0.6596
- val_loss: 0.6234 - learning_rate: 0.0050
Epoch 9/15
27/27 - 3s - 93ms/step - accuracy: 0.7220 - loss: 0.5496 - val_accuracy: 0.6277
- val_loss: 0.6000 - learning_rate: 0.0050
Epoch 10/15
27/27 - 3s - 95ms/step - accuracy: 0.6843 - loss: 0.5992 - val_accuracy: 0.6064
- val_loss: 0.6534 - learning_rate: 0.0050
Epoch 11/15
27/27 - 3s - 99ms/step - accuracy: 0.6996 - loss: 0.5705 - val_accuracy: 0.6277
- val_loss: 0.6094 - learning_rate: 0.0050
Epoch 12/15
27/27 - 3s - 99ms/step - accuracy: 0.6949 - loss: 0.5841 - val_accuracy: 0.7128
- val_loss: 0.6014 - learning_rate: 0.0050
Epoch 13/15
27/27 - 3s - 97ms/step - accuracy: 0.7008 - loss: 0.5939 - val_accuracy: 0.7234
- val_loss: 0.5682 - learning_rate: 0.0050
Epoch 14/15
27/27 - 3s - 99ms/step - accuracy: 0.6396 - loss: 0.6213 - val_accuracy: 0.5957
- val_loss: 0.6512 - learning_rate: 0.0050
Epoch 15/15
27/27 - 3s - 103ms/step - accuracy: 0.6784 - loss: 0.5955 - val_accuracy: 0.6915
- val_loss: 0.5860 - learning_rate: 0.0050

```

```

[18]: #from tensorflow.keras.models import load_model
      #model.save('gender_recognition_project04_v10.h5')

```

```

[19]: model.metrics_names

```



```
[19]: ['loss', 'compile_metrics']
```

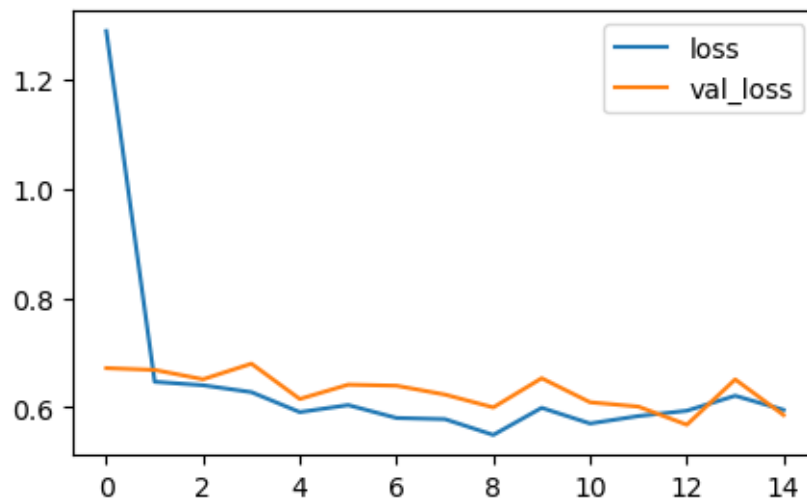
```
[20]: result_history = pd.DataFrame(model.history.history)
result_history.head(15)
```

```
[20]:
```

| | accuracy | loss | val_accuracy | val_loss | learning_rate |
|----|----------|----------|--------------|----------|---------------|
| 0 | 0.546525 | 1.288779 | 0.585106 | 0.671890 | 0.005 |
| 1 | 0.644287 | 0.646841 | 0.617021 | 0.668541 | 0.005 |
| 2 | 0.631331 | 0.640516 | 0.627660 | 0.651437 | 0.005 |
| 3 | 0.652532 | 0.627866 | 0.595745 | 0.679980 | 0.005 |
| 4 | 0.684335 | 0.591316 | 0.617021 | 0.615375 | 0.005 |
| 5 | 0.663133 | 0.604221 | 0.680851 | 0.641575 | 0.005 |
| 6 | 0.693757 | 0.580595 | 0.617021 | 0.639675 | 0.005 |
| 7 | 0.690224 | 0.578458 | 0.659574 | 0.623439 | 0.005 |
| 8 | 0.722026 | 0.549574 | 0.627660 | 0.599970 | 0.005 |
| 9 | 0.684335 | 0.599190 | 0.606383 | 0.653352 | 0.005 |
| 10 | 0.699647 | 0.570492 | 0.627660 | 0.609356 | 0.005 |
| 11 | 0.694935 | 0.584141 | 0.712766 | 0.601409 | 0.005 |
| 12 | 0.700824 | 0.593862 | 0.723404 | 0.568219 | 0.005 |
| 13 | 0.639576 | 0.621326 | 0.595745 | 0.651201 | 0.005 |
| 14 | 0.678445 | 0.595458 | 0.691489 | 0.586022 | 0.005 |

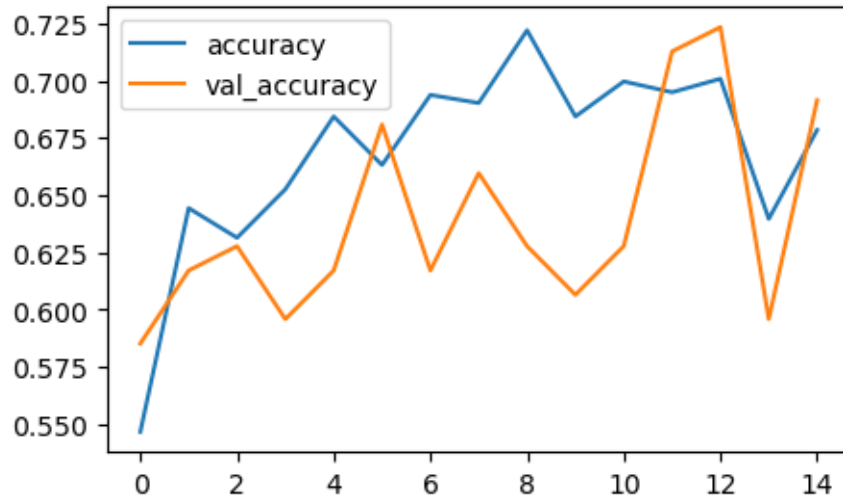
```
[21]: result_history[['loss', 'val_loss']].plot(figsize=(5, 3))
```

```
[21]: <Axes: >
```



```
[22]: result_history[['accuracy', 'val_accuracy']].plot(figsize=(5, 3))
```

```
[22]: <Axes: >
```



```
[23]: print(model.metrics_names)
      print(model.evaluate(validation_dataset))
```

```
['loss', 'compile_metrics']
3/3          0s 32ms/step -
accuracy: 0.6700 - loss: 0.6207
[0.5860221982002258, 0.6914893388748169]
```

```
[24]: from sklearn.metrics import classification_report, confusion_matrix

y_true = np.concatenate([y.numpy() for _, y in validation_dataset])
y_pred_prob = model.predict(validation_dataset)
# Convert probabilities to class labels (0:Female or 1:Male)
y_pred = (y_pred_prob > 0.5).astype(int).flatten()

print("Classification Report:\n", classification_report(y_true, y_pred,
    target_names=['Female', 'Male']))
```

```
3/3          0s 59ms/step
Classification Report:
      precision    recall  f1-score   support

   Female       0.65       0.63       0.64         41
    Male       0.72       0.74       0.73         53

   accuracy                0.69         94
  macro avg       0.69       0.68       0.69         94
 weighted avg       0.69       0.69       0.69         94
```

```

[25]: import tensorflow as tf
import numpy as np
import matplotlib.pyplot as plt
from tensorflow.keras.models import Model
from tensorflow.keras.utils import load_img, img_to_array

img_size = img_size
model = tf.keras.models.load_model("gender_recognition_project04_v10.h5")

# Load your personal image if you are interested to predict:
your_image_path = "D:\\Hossein's desktop files in Microsoft Studio_
↳Laptop\\Personal Photos\\Hossein_10.jpg"

img = load_img(your_image_path, target_size=(img_size, img_size))
final_img = img_to_array(img)
# Adding a batch dimension:
final_img = np.expand_dims(final_img, axis=0)
prediction = model.predict(final_img)
result = "Female" if prediction > 0.5 else "Male"
if result=="Female":
    confidence = (model.predict(final_img)[0][0])*100
else:
    confidence = (1-model.predict(final_img)[0][0])*100
print(f"Prediction result: {result} (confidence= {confidence:.2f} %)")

# Visualize CNN Layers
successive_feature_maps = visualization_model.predict(final_img)
layer_names = [layer.name for layer in model.layers]

for layer_name, feature_map in zip(layer_names, successive_feature_maps):
    if len(feature_map.shape) == 4: # Only visualize conv/maxpool layers
        n_features = feature_map.shape[-1] # Number of filters
        size = feature_map.shape[1] # Feature map size
        display_grid = np.zeros((size, size * n_features))

        for i in range(n_features):
            x = feature_map[0, :, :, i]
            x -= x.mean()
            x /= (x.std() + 1e-8) # Normalize
            x *= 64
            x += 128
            x = np.clip(x, 0, 255).astype('uint8') # Convert to image format
            display_grid[:, i * size: (i + 1) * size] = x

        scale = 20. / n_features
        plt.figure(figsize=(scale * n_features, scale))
        plt.title(layer_name)

```

```
plt.grid(False)
plt.imshow(display_grid, aspect='auto', cmap='cividis')
plt.show()
```

WARNING:absl:Compiled the loaded model, but the compiled metrics have yet to be built. `model.compile_metrics` will be empty until you train or evaluate the model.

1/1 0s 83ms/step

1/1 0s 35ms/step

Prediction result: Male (confidence= 94.19 %)

```
-----
NameError                                Traceback (most recent call last)
Cell In[25], line 26
    23 print(f"Prediction result: {result} (confidence= {confidence:.2f} %)")
    25 # Visualize CNN Layers
----> 26 successive_feature_maps = visualization_model.predict(final_img)
    27 layer_names = [layer.name for layer in model.layers]
    29 for layer_name, feature_map in zip(layer_names, successive_feature_maps :

NameError: name 'visualization_model' is not defined
```

[]:

[]:

[]: