# Personal Project_04_v10_test1_3conv-layer_run16_advanced control 1

May 2, 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 = 0.0005
dropout_value = 0.5
# n-conv_layers = 4
n_units_last_layer = 4096
n_filters_l1 = 8
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 = 20
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]:
```python
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]:
```python
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]:
```
'\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:
        if epoch % 5 == 0 and epoch > 0:
            return lr / 1
        return lr
    elif epoch < 30:
        if epoch % 5 == 0 and epoch > 0:
            return lr / 1.2
        return lr
    elif epoch < 40:
        if epoch % 5 == 0 and epoch > 0:
            return lr / 1.1
        return lr
    else:
```

```
        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, 8) | 392 |
| max_pooling2d (MaxPooling2D) | (None, 63, 63, 8) | 0 |
| conv2d_1 (Conv2D) | (None, 61, 61, 64) | 4,672 |
| 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, 4096) | 9,441,280 |
| dense_1 (Dense) | (None, 1) | 4,097 |

**Total params:** 9,524,297 (36.33 MB)

**Trainable params:** 9,524,297 (36.33 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 1/20
27/27 - 5s - 171ms/step - accuracy: 0.5913 - loss: 0.6845 - val_accuracy: 0.5532
- val_loss: 0.7082 - learning_rate: 5.0000e-04
Epoch 2/20
27/27 - 2s - 87ms/step - accuracy: 0.6867 - loss: 0.5977 - val_accuracy: 0.7021
- val_loss: 0.5649 - learning_rate: 5.0000e-04
Epoch 3/20
27/27 - 2s - 85ms/step - accuracy: 0.7102 - loss: 0.5627 - val_accuracy: 0.7447
- val_loss: 0.5695 - learning_rate: 5.0000e-04
Epoch 4/20
27/27 - 2s - 89ms/step - accuracy: 0.7479 - loss: 0.5288 - val_accuracy: 0.7553
- val_loss: 0.5102 - learning_rate: 5.0000e-04
Epoch 5/20
27/27 - 2s - 87ms/step - accuracy: 0.7432 - loss: 0.5101 - val_accuracy: 0.8085
- val_loss: 0.4816 - learning_rate: 5.0000e-04
Epoch 6/20
27/27 - 2s - 85ms/step - accuracy: 0.7432 - loss: 0.5080 - val_accuracy: 0.8404
- val_loss: 0.4814 - learning_rate: 5.0000e-04
Epoch 7/20
27/27 - 2s - 84ms/step - accuracy: 0.7797 - loss: 0.4703 - val_accuracy: 0.8085
- val_loss: 0.4981 - learning_rate: 5.0000e-04
Epoch 8/20
27/27 - 2s - 85ms/step - accuracy: 0.7762 - loss: 0.4494 - val_accuracy: 0.7872
- val_loss: 0.4463 - learning_rate: 5.0000e-04
Epoch 9/20
27/27 - 2s - 86ms/step - accuracy: 0.7939 - loss: 0.4376 - val_accuracy: 0.8298
- val_loss: 0.3891 - learning_rate: 5.0000e-04
Epoch 10/20
27/27 - 2s - 85ms/step - accuracy: 0.8092 - loss: 0.3927 - val_accuracy: 0.7660
- val_loss: 0.6258 - learning_rate: 5.0000e-04
Epoch 11/20
27/27 - 2s - 86ms/step - accuracy: 0.8104 - loss: 0.4184 - val_accuracy: 0.8191
- val_loss: 0.4744 - learning_rate: 4.1667e-04
Epoch 12/20
27/27 - 2s - 84ms/step - accuracy: 0.8292 - loss: 0.3838 - val_accuracy: 0.8298
- val_loss: 0.4207 - learning_rate: 4.1667e-04
```

```
Epoch 13/20
27/27 - 2s - 85ms/step - accuracy: 0.8375 - loss: 0.3758 - val_accuracy: 0.8191
- val_loss: 0.3963 - learning_rate: 4.1667e-04
Epoch 14/20
27/27 - 2s - 85ms/step - accuracy: 0.8563 - loss: 0.3515 - val_accuracy: 0.8404
- val_loss: 0.4095 - learning_rate: 4.1667e-04
Epoch 15/20
27/27 - 2s - 86ms/step - accuracy: 0.8398 - loss: 0.3508 - val_accuracy: 0.8404
- val_loss: 0.3723 - learning_rate: 4.1667e-04
Epoch 16/20
27/27 - 2s - 86ms/step - accuracy: 0.8716 - loss: 0.3308 - val_accuracy: 0.8936
- val_loss: 0.4032 - learning_rate: 3.4722e-04
Epoch 17/20
27/27 - 2s - 85ms/step - accuracy: 0.8339 - loss: 0.3587 - val_accuracy: 0.8617
- val_loss: 0.3863 - learning_rate: 3.4722e-04
Epoch 18/20
27/27 - 2s - 85ms/step - accuracy: 0.8528 - loss: 0.3291 - val_accuracy: 0.8723
- val_loss: 0.4041 - learning_rate: 3.4722e-04
Epoch 19/20
27/27 - 2s - 85ms/step - accuracy: 0.8634 - loss: 0.3008 - val_accuracy: 0.7979
- val_loss: 0.3761 - learning_rate: 3.4722e-04
Epoch 20/20
27/27 - 2s - 85ms/step - accuracy: 0.8563 - loss: 0.3114 - val_accuracy: 0.8723
- val_loss: 0.3607 - learning_rate: 3.4722e-04
```

[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)
```

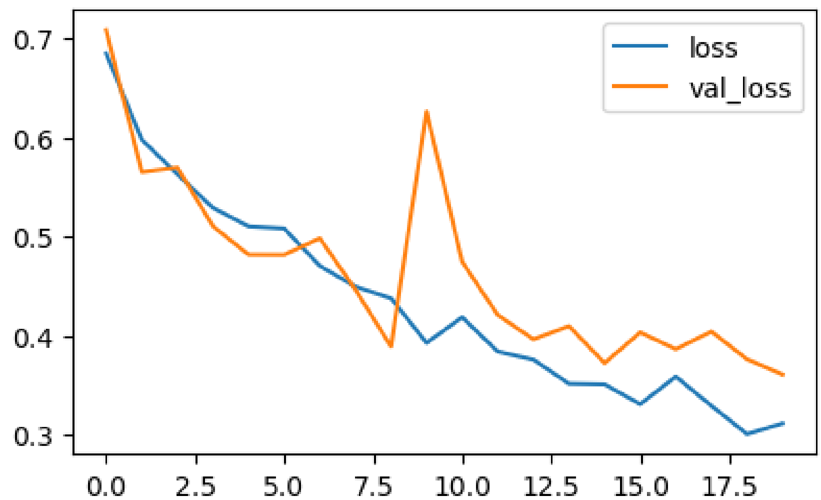
[20]:

| | accuracy | loss | val_accuracy | val_loss | learning_rate |
|---|---|---|---|---|---|
| 0 | 0.591284 | 0.684490 | 0.553191 | 0.708180 | 0.000500 |
| 1 | 0.686690 | 0.597668 | 0.702128 | 0.564949 | 0.000500 |
| 2 | 0.710247 | 0.562719 | 0.744681 | 0.569503 | 0.000500 |
| 3 | 0.747939 | 0.528787 | 0.755319 | 0.510222 | 0.000500 |
| 4 | 0.743227 | 0.510139 | 0.808511 | 0.481564 | 0.000500 |
| 5 | 0.743227 | 0.508042 | 0.840426 | 0.481415 | 0.000500 |
| 6 | 0.779741 | 0.470272 | 0.808511 | 0.498130 | 0.000500 |
| 7 | 0.776207 | 0.449389 | 0.787234 | 0.446304 | 0.000500 |
| 8 | 0.793875 | 0.437624 | 0.829787 | 0.389065 | 0.000500 |
| 9 | 0.809187 | 0.392655 | 0.765957 | 0.625812 | 0.000500 |
| 10 | 0.810365 | 0.418447 | 0.819149 | 0.474382 | 0.000417 |
| 11 | 0.829211 | 0.383821 | 0.829787 | 0.420678 | 0.000417 |

| | | | | | |
|---|---|---|---|---|---|
| 12 | 0.837456 | 0.375755 | 0.819149 | 0.396266 | 0.000417 |
| 13 | 0.856302 | 0.351455 | 0.840426 | 0.409475 | 0.000417 |
| 14 | 0.839812 | 0.350824 | 0.840426 | 0.372253 | 0.000417 |

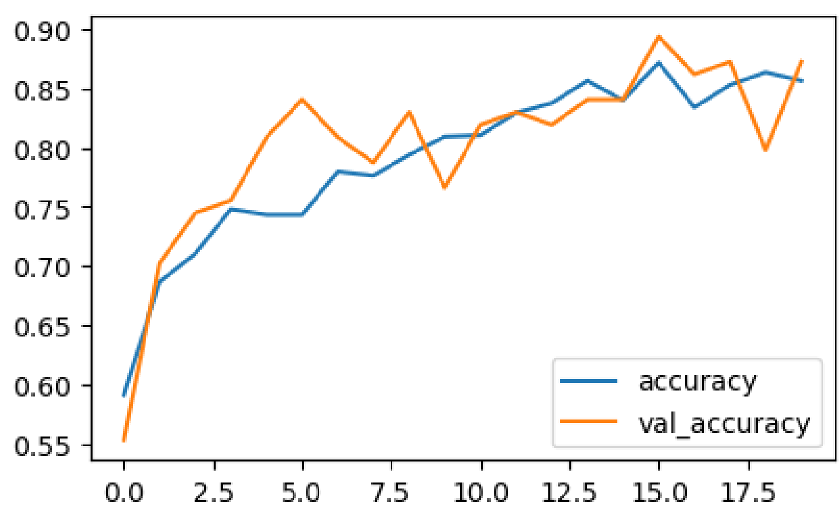
[21]:
```
result_history[['loss', 'val_loss']].plot(figsize=(5, 3))
```

[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 41ms/step -
accuracy: 0.8580 - loss: 0.3955
[0.3606766164302826, 0.8723404407501221]
```

[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 71ms/step
Classification Report:
               precision    recall  f1-score   support

      Female       0.82      0.90      0.86        41
        Male       0.92      0.85      0.88        53

    accuracy                           0.87        94
   macro avg       0.87      0.88      0.87        94
weighted avg       0.88      0.87      0.87        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)
```

```python
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 157ms/step
1/1              0s 59ms/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
```

[ ]:

[ ]:

[ ]: