

```
In [3]: pip install optuna
```

```
Defaulting to user installation because normal site-packages is not writeable
Collecting optuna
  Using cached optuna-3.4.0-py3-none-any.whl (409 kB)
Collecting sqlalchemy>=1.3.0
  Downloading SQLAlchemy-2.0.23-cp38-cp38-manylinux_2_17_x86_64.manylinux2014_x86_64.whl (3.1 MB)
  3.1/3.1 MB 28.1 MB/s eta 0:00:000:0100:01
Requirement already satisfied: tqdm in /packages/envs/tensorflow-gpu-2.10.0/lib/python3.8/site-packages (from optuna) (4.65.0)
Requirement already satisfied: numpy in /packages/envs/tensorflow-gpu-2.10.0/lib/python3.8/site-packages (from optuna) (1.23.5)
Requirement already satisfied: packaging>=20.0 in /packages/envs/tensorflow-gpu-2.10.0/lib/python3.8/site-packages (from optuna) (21.3)
Collecting colorlog
  Using cached colorlog-6.8.0-py3-none-any.whl (11 kB)
Requirement already satisfied: PyYAML in /packages/envs/tensorflow-gpu-2.10.0/lib/python3.8/site-packages (from optuna) (6.0.1)
Collecting alembic>=1.5.0
  Using cached alembic-1.13.0-py3-none-any.whl (230 kB)
Requirement already satisfied: importlib-metadata in /packages/envs/tensorflow-gpu-2.10.0/lib/python3.8/site-packages (from alembic>=1.5.0->optuna) (5.1.0)
Requirement already satisfied: importlib-resources in /packages/envs/tensorflow-gpu-2.10.0/lib/python3.8/site-packages (from alembic>=1.5.0->optuna) (5.10.0)
Requirement already satisfied: typing-extensions>=4 in /packages/envs/tensorflow-gpu-2.10.0/lib/python3.8/site-packages (from alembic>=1.5.0->optuna) (4.4.0)
Collecting Mako
  Using cached Mako-1.3.0-py3-none-any.whl (78 kB)
Requirement already satisfied: pyparsing!=3.0.5,>=2.0.2 in /packages/envs/tensorflow-gpu-2.10.0/lib/python3.8/site-packages (from packaging>=20.0->optuna) (3.0.9)
Collecting greenlet!=0.4.17
  Downloading greenlet-3.0.1-cp38-cp38-manylinux_2_24_x86_64.manylinux_2_28_x86_64.whl (618 kB)
  618.6/618.6 kB 42.4 MB/s eta 0:00:00
Requirement already satisfied: zipp>=0.5 in /packages/envs/tensorflow-gpu-2.10.0/lib/python3.8/site-packages (from importlib-metadata->alembic>=1.5.0->optuna) (3.11.0)
Requirement already satisfied: MarkupSafe>=0.9.2 in /packages/envs/tensorflow-gpu-2.10.0/lib/python3.8/site-packages (from Mako->alembic>=1.5.0->optuna) (2.1.1)
Installing collected packages: Mako, greenlet, colorlog, sqlalchemy, alembic, optuna
Successfully installed Mako-1.3.0 alembic-1.13.0 colorlog-6.8.0 greenlet-3.0.1 optuna-3.4.0 sqlalchemy-2.0.23
Note: you may need to restart the kernel to use updated packages.
```

```
In [4]: import matplotlib.pyplot as plt
import numpy as np
import PIL
import tensorflow as tf
from os import listdir
from PIL import Image as PImage
import os
import pathlib
import optuna

from tensorflow import keras
from tensorflow.keras import layers
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import BatchNormalization, Dropout, Conv2D, MaxPooling2D, Flatten, Dense
from sklearn.model_selection import KFold
```

```
In [5]: # For Local testing, copy and paste the directory where your data is.
train_path = "/home/jgoh4/card_clf/train/"
data_dir_train = pathlib.Path(train_path).with_suffix('')
val_path = "/home/jgoh4/card_clf/valid/"
data_dir_val = pathlib.Path(val_path).with_suffix('')
test_path = "/home/jgoh4/card_clf/test/"
data_dir_test = pathlib.Path(test_path).with_suffix('')
```

```
In [6]: # Count how many images in total there are
image_count = len(list(data_dir_train.glob('*/*.jpg')))
print("Image Count: ", image_count)
```

Image Count: 7624

```
In [7]: # Here we read the TRAIN .png images into a dataset (non-tabular, presumably) formatted as tensors
train_ds = tf.keras.utils.image_dataset_from_directory(
    data_dir_train,
    image_size = (224,224))
```

Found 7624 files belonging to 53 classes.

```
2023-12-05 13:45:08.052665: I tensorflow/core/platform/cpu_feature_guard.cc:193] This TensorFlow binary is optimized with oneAPI Deep Neural Network Library (oneDNN) to use the following CPU instructions in performance-critical operations: SSE4.1 SSE4.2 AVX AVX2 FMA
To enable them in other operations, rebuild TensorFlow with the appropriate compiler flags.
2023-12-05 13:45:08.545252: I tensorflow/core/common_runtime/gpu/gpu_device.cc:1616] Created device /job:localhost/relica:0/task:0/device:GPU:0 with 78962 MB memory: -> device: 0, name: NVIDIA A100-SXM4-80GB, pci bus id: 0000:81:00.0, compute capability: 8.0
```

```
In [8]: print(train_ds)

<BatchDataset element_spec=(TensorSpec(shape=(None, 224, 224, 3), dtype=tf.float32, name=None), TensorSpec(shape=(None,), dtype=tf.int32, name=None))>
```

```
In [9]: # Here we read the VALIDATION .png images into a dataset (non-tabular, presumably) formatted as tensors
val_ds = tf.keras.utils.image_dataset_from_directory(
    data_dir_val,
    image_size = (224,224)
)
```

Found 265 files belonging to 53 classes.

```
In [10]: # Here we read the TEST .png images into a dataset (non-tabular, presumably) formatted as tensors
test_ds = tf.keras.utils.image_dataset_from_directory(
    data_dir_test,
    image_size = (224,224)
)
```

Found 7624 files belonging to 53 classes.

```
In [11]: class_names = train_ds.class_names
print(class_names) # same as labels

['ace of clubs', 'ace of diamonds', 'ace of hearts', 'ace of spades', 'eight of clubs', 'eight of diamonds', 'eight of hearts', 'eight of spades', 'five of clubs', 'five of diamonds', 'five of hearts', 'five of spades', 'four of clubs', 'four of diamonds', 'four of hearts', 'four of spades', 'jack of clubs', 'jack of diamonds', 'jack of hearts', 'jack of spades', 'joker', 'king of clubs', 'king of diamonds', 'king of hearts', 'king of spades', 'nine of clubs', 'nine of diamonds', 'nine of hearts', 'nine of spades', 'queen of clubs', 'queen of diamonds', 'queen of hearts', 'queen of spades', 'seven of clubs', 'seven of diamonds', 'seven of hearts', 'seven of spades', 'six of clubs', 'six of diamonds', 'six of hearts', 'six of spades', 'ten of clubs', 'ten of diamonds', 'ten of hearts', 'ten of spades', 'three of clubs', 'three of diamonds', 'three of hearts', 'three of spades', 'two of clubs', 'two of diamonds', 'two of hearts', 'two of spades']
```

```
In [12]: num_classes = len(class_names)
```

```
In [13]: def create_model(trial):
    # Define the model architecture with trial-suggested hyperparameters
    model = Sequential()
    model.add(layers.Rescaling(1./255, input_shape=(224, 224, 3)))
    model.add(Conv2D(filters=trial.suggest_categorical('filters_1', [16, 32, 64]),
                    kernel_size=3,
                    activation='relu',
                    ))
    model.add(MaxPooling2D(pool_size=2))

    model.add(Conv2D(filters=trial.suggest_categorical('filters_2', [32, 64, 128]),
                    kernel_size=3,
                    activation='relu'))
    model.add(MaxPooling2D(pool_size=2))

    model.add(Conv2D(filters=trial.suggest_categorical('filters_2', [32, 64, 128]),
                    kernel_size=3,
                    activation='relu'))
    model.add(MaxPooling2D(pool_size=2))

    model.add(Flatten())
    model.add(Dense(units=trial.suggest_categorical('units', [64, 128, 256]),
                   activation='relu'))
    model.add(Dropout(rate=trial.suggest_float('dropout', 0.2, 0.5)))
    model.add(Dense(53, activation='softmax'))
    return model

def objective(trial):
    model = create_model(trial)

    # Compile, train, and evaluate the model
    model.compile(optimizer='adam', loss='sparse_categorical_crossentropy', metrics=['accuracy'])
    model.fit(train_ds, epochs=5, validation_data=val_ds)

    _, accuracy = model.evaluate(val_ds, verbose=0)
    return accuracy

study = optuna.create_study(direction='maximize')
study.optimize(objective, n_trials=50)

print('Best trial:', study.best_trial.params)
```

```
[I 2023-12-05 13:45:10,596] A new study created in memory with name: no-name-21ca0e55-ce9c-47a6-9583-ede2f6667712
Epoch 1/5
```

```
2023-12-05 13:45:18.209150: I tensorflow/stream_executor/cuda/cuda_dnn.cc:384] Loaded cuDNN version 8401
2023-12-05 13:45:24.458882: I tensorflow/core/platform/default/subprocess.cc:304] Start cannot spawn child process: No such file or directory
2023-12-05 13:45:24.766089: I tensorflow/stream_executor/cuda/cuda_blas.cc:1614] TensorFloat-32 will be used for the matrix multiplication. This will only be logged once.
```

```
239/239 [=====] - 32s 61ms/step - loss: 3.0308 - accuracy: 0.2423 - val_loss: 1.6917 - val_accuracy: 0.5358
```

```
Epoch 2/5
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```
239/239 [=====] - 5s 20ms/step - loss: 1.7952 - accuracy: 0.5232 - val_loss: 1.1515 - val_accuracy: 0.7019
```

```
Epoch 3/5
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```
239/239 [=====] - 5s 22ms/step - loss: 1.1967 - accuracy: 0.6733 - val_loss: 1.0783 - val_accuracy: 0.7321
```

```
Epoch 4/5
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```
239/239 [=====] - 5s 21ms/step - loss: 0.8122 - accuracy: 0.7792 - val_loss: 1.0993 - val_accuracy: 0.7660
```

```
Epoch 5/5
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239/239 [=====] - 5s 21ms/step - loss: 0.5425 - accuracy: 0.8464 - val_loss: 1.0998 - val_accuracy: 0.7509
```

```
[I 2023-12-05 13:46:02,912] Trial 0 finished with value: 0.7509434223175049 and parameters: {'filters_1': 32, 'filters_2': 128, 'units': 256, 'dropout': 0.44481558460000753}. Best is trial 0 with value: 0.7509434223175049.
```

```
Epoch 1/5
```

```
239/239 [=====] - 7s 23ms/step - loss: 3.2910 - accuracy: 0.1714 - val_loss: 1.9186 - val_accuracy: 0.4415
```

```
Epoch 2/5
```

```
239/239 [=====] - 5s 20ms/step - loss: 2.1186 - accuracy: 0.4267 - val_loss: 1.3697 - val_accuracy: 0.6340
```

```
Epoch 3/5
```

```
239/239 [=====] - 5s 21ms/step - loss: 1.5243 - accuracy: 0.5699 - val_loss: 1.1160 - val_accuracy: 0.6906
```

```
Epoch 4/5
```

```
239/239 [=====] - 5s 21ms/step - loss: 1.1309 - accuracy: 0.6730 - val_loss: 1.0610 - val_accuracy: 0.7170
```

```
Epoch 5/5
```

```
239/239 [=====] - 5s 20ms/step - loss: 0.8975 - accuracy: 0.7303 - val_loss: 1.0771 - val_accuracy: 0.7321
```

```
[I 2023-12-05 13:46:30,539] Trial 1 finished with value: 0.7320754528045654 and parameters: {'filters_1': 64, 'filters_2': 64, 'units': 64, 'dropout': 0.2312295156089803}. Best is trial 0 with value: 0.7509434223175049.
```

```
Epoch 1/5
239/239 [=====] - 5s 20ms/step - loss: 2.9685 - accuracy: 0.2617 - val_loss: 1.5313 - val_accuracy: 0.5660
Epoch 2/5
239/239 [=====] - 5s 20ms/step - loss: 1.6809 - accuracy: 0.5500 - val_loss: 1.0857 - val_accuracy: 0.7132
Epoch 3/5
239/239 [=====] - 5s 20ms/step - loss: 1.0432 - accuracy: 0.7099 - val_loss: 0.8872 - val_accuracy: 0.7660
Epoch 4/5
239/239 [=====] - 5s 21ms/step - loss: 0.6248 - accuracy: 0.8208 - val_loss: 1.0090 - val_accuracy: 0.7547
Epoch 5/5
239/239 [=====] - 5s 20ms/step - loss: 0.3994 - accuracy: 0.8892 - val_loss: 1.0544 - val_accuracy: 0.7887
[I 2023-12-05 13:46:56,164] Trial 2 finished with value: 0.7886792421340942 and parameters: {'filters_1': 32, 'filters_2': 128, 'units': 256, 'dropout': 0.3947076864731943}. Best is trial 2 with value: 0.7886792421340942.
Epoch 1/5
239/239 [=====] - 5s 21ms/step - loss: 2.7265 - accuracy: 0.3078 - val_loss: 1.4000 - val_accuracy: 0.5962
Epoch 2/5
239/239 [=====] - 5s 20ms/step - loss: 1.5260 - accuracy: 0.5900 - val_loss: 0.9618 - val_accuracy: 0.7321
Epoch 3/5
239/239 [=====] - 5s 21ms/step - loss: 0.8621 - accuracy: 0.7562 - val_loss: 1.0704 - val_accuracy: 0.7509
Epoch 4/5
239/239 [=====] - 5s 21ms/step - loss: 0.4510 - accuracy: 0.8743 - val_loss: 1.1314 - val_accuracy: 0.7774
Epoch 5/5
239/239 [=====] - 5s 20ms/step - loss: 0.2943 - accuracy: 0.9222 - val_loss: 0.9989 - val_accuracy: 0.8151
[I 2023-12-05 13:47:21,964] Trial 3 finished with value: 0.8150943517684937 and parameters: {'filters_1': 32, 'filters_2': 128, 'units': 256, 'dropout': 0.22074055843942908}. Best is trial 3 with value: 0.8150943517684937.
```

```
Epoch 1/5
239/239 [=====] - 6s 22ms/step - loss: 3.3298 - accuracy: 0.1573 - val_loss: 1.8823 - val_accuracy: 0.4792
Epoch 2/5
239/239 [=====] - 5s 20ms/step - loss: 2.2639 - accuracy: 0.3789 - val_loss: 1.3025 - val_accuracy: 0.6377
Epoch 3/5
239/239 [=====] - 5s 20ms/step - loss: 1.7732 - accuracy: 0.5135 - val_loss: 1.1008 - val_accuracy: 0.7132
Epoch 4/5
239/239 [=====] - 6s 23ms/step - loss: 1.4510 - accuracy: 0.5887 - val_loss: 1.0142 - val_accuracy: 0.7434
Epoch 5/5
239/239 [=====] - 5s 19ms/step - loss: 1.1565 - accuracy: 0.6649 - val_loss: 1.0064 - val_accuracy: 0.7472
[I 2023-12-05 13:47:47,822] Trial 4 finished with value: 0.7471697926521301 and parameters: {'filters_1': 32, 'filters_2': 128, 'units': 64, 'dropout': 0.3286312608366055}. Best is trial 3 with value: 0.8150943517684937.
Epoch 1/5
239/239 [=====] - 6s 19ms/step - loss: 2.7289 - accuracy: 0.3005 - val_loss: 1.3938 - val_accuracy: 0.6075
Epoch 2/5
239/239 [=====] - 5s 18ms/step - loss: 1.5004 - accuracy: 0.6010 - val_loss: 1.0018 - val_accuracy: 0.7245
Epoch 3/5
239/239 [=====] - 5s 19ms/step - loss: 0.7844 - accuracy: 0.7815 - val_loss: 0.9356 - val_accuracy: 0.7585
Epoch 4/5
239/239 [=====] - 5s 19ms/step - loss: 0.4240 - accuracy: 0.8842 - val_loss: 0.9454 - val_accuracy: 0.7849
Epoch 5/5
239/239 [=====] - 5s 19ms/step - loss: 0.3040 - accuracy: 0.9254 - val_loss: 0.9564 - val_accuracy: 0.7925
[I 2023-12-05 13:48:12,456] Trial 5 finished with value: 0.7924528121948242 and parameters: {'filters_1': 16, 'filters_2': 128, 'units': 256, 'dropout': 0.2636389989040727}. Best is trial 3 with value: 0.8150943517684937.
```

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Epoch 1/5
239/239 [=====] - 8s 25ms/step - loss: 3.3872 - accuracy: 0.1498 - val_loss: 2.0083 - val_accuracy: 0.4075
Epoch 2/5
239/239 [=====] - 6s 23ms/step - loss: 2.3053 - accuracy: 0.3679 - val_loss: 1.4414 - val_accuracy: 0.5774
Epoch 3/5
239/239 [=====] - 6s 24ms/step - loss: 1.8349 - accuracy: 0.4815 - val_loss: 1.2730 - val_accuracy: 0.6189
Epoch 4/5
239/239 [=====] - 6s 23ms/step - loss: 1.4901 - accuracy: 0.5708 - val_loss: 1.0667 - val_accuracy: 0.7094
Epoch 5/5
239/239 [=====] - 6s 23ms/step - loss: 1.2112 - accuracy: 0.6384 - val_loss: 1.0695 - val_accuracy: 0.7132
[I 2023-12-05 13:48:43,971] Trial 6 finished with value: 0.7132075428962708 and parameters: {'filters_1': 64, 'filters_2': 128, 'units': 64, 'dropout': 0.3131997916349555}. Best is trial 3 with value: 0.8150943517684937.
Epoch 1/5
239/239 [=====] - 5s 20ms/step - loss: 3.7756 - accuracy: 0.0618 - val_loss: 3.0387 - val_accuracy: 0.2264
Epoch 2/5
239/239 [=====] - 5s 19ms/step - loss: 3.1910 - accuracy: 0.1826 - val_loss: 2.4018 - val_accuracy: 0.3736
Epoch 3/5
239/239 [=====] - 5s 20ms/step - loss: 2.6403 - accuracy: 0.2867 - val_loss: 1.6013 - val_accuracy: 0.5698
Epoch 4/5
239/239 [=====] - 5s 20ms/step - loss: 2.1326 - accuracy: 0.3881 - val_loss: 1.1503 - val_accuracy: 0.6717
Epoch 5/5
239/239 [=====] - 5s 19ms/step - loss: 1.7908 - accuracy: 0.4728 - val_loss: 0.9200 - val_accuracy: 0.7321
[I 2023-12-05 13:49:09,057] Trial 7 finished with value: 0.7320754528045654 and parameters: {'filters_1': 32, 'filters_2': 128, 'units': 64, 'dropout': 0.45736969514120784}. Best is trial 3 with value: 0.8150943517684937.
```

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Epoch 1/5
239/239 [=====] - 5s 18ms/step - loss: 2.7856 - accuracy: 0.2862 - val_loss: 1.4810 - val_accuracy: 0.5698
Epoch 2/5
239/239 [=====] - 4s 17ms/step - loss: 1.5821 - accuracy: 0.5717 - val_loss: 1.1196 - val_accuracy: 0.6830
Epoch 3/5
239/239 [=====] - 4s 18ms/step - loss: 0.8979 - accuracy: 0.7509 - val_loss: 1.1860 - val_accuracy: 0.7170
Epoch 4/5
239/239 [=====] - 4s 17ms/step - loss: 0.5090 - accuracy: 0.8607 - val_loss: 1.3357 - val_accuracy: 0.7434
Epoch 5/5
239/239 [=====] - 4s 17ms/step - loss: 0.3567 - accuracy: 0.9040 - val_loss: 1.2197 - val_accuracy: 0.7472
[I 2023-12-05 13:49:31,586] Trial 8 finished with value: 0.7471697926521301 and parameters: {'filters_1': 32, 'filters_2': 64, 'units': 256, 'dropout': 0.31114494697734885}. Best is trial 3 with value: 0.8150943517684937.
Epoch 1/5
239/239 [=====] - 6s 21ms/step - loss: 3.2401 - accuracy: 0.1805 - val_loss: 1.7980 - val_accuracy: 0.5132
Epoch 2/5
239/239 [=====] - 5s 19ms/step - loss: 2.1204 - accuracy: 0.4277 - val_loss: 1.2519 - val_accuracy: 0.6679
Epoch 3/5
239/239 [=====] - 5s 19ms/step - loss: 1.5651 - accuracy: 0.5622 - val_loss: 1.0457 - val_accuracy: 0.7283
Epoch 4/5
239/239 [=====] - 5s 19ms/step - loss: 1.2002 - accuracy: 0.6552 - val_loss: 1.0061 - val_accuracy: 0.7509
Epoch 5/5
239/239 [=====] - 5s 19ms/step - loss: 0.9361 - accuracy: 0.7145 - val_loss: 1.0340 - val_accuracy: 0.7509
[I 2023-12-05 13:49:56,120] Trial 9 finished with value: 0.7509434223175049 and parameters: {'filters_1': 64, 'filters_2': 32, 'units': 64, 'dropout': 0.32419319353641757}. Best is trial 3 with value: 0.8150943517684937.
```

```
Epoch 1/5
239/239 [=====] - 4s 17ms/step - loss: 3.0181 - accuracy: 0.2285 - val_loss: 1.7148 - val_accuracy: 0.5019
Epoch 2/5
239/239 [=====] - 4s 16ms/step - loss: 1.9131 - accuracy: 0.4848 - val_loss: 1.2450 - val_accuracy: 0.6566
Epoch 3/5
239/239 [=====] - 4s 16ms/step - loss: 1.3217 - accuracy: 0.6325 - val_loss: 1.0795 - val_accuracy: 0.7358
Epoch 4/5
239/239 [=====] - 4s 17ms/step - loss: 0.8791 - accuracy: 0.7463 - val_loss: 0.9689 - val_accuracy: 0.7623
Epoch 5/5
239/239 [=====] - 4s 16ms/step - loss: 0.5811 - accuracy: 0.8315 - val_loss: 0.9038 - val_accuracy: 0.7887
[I 2023-12-05 13:50:17,193] Trial 10 finished with value: 0.7886792421340942 and parameters: {'filters_1': 16, 'filters_2': 32, 'units': 128, 'dropout': 0.25823699317965654}. Best is trial 3 with value: 0.8150943517684937.
Epoch 1/5
239/239 [=====] - 5s 19ms/step - loss: 2.9159 - accuracy: 0.2483 - val_loss: 1.3991 - val_accuracy: 0.6415
Epoch 2/5
239/239 [=====] - 5s 20ms/step - loss: 1.4536 - accuracy: 0.6065 - val_loss: 1.0391 - val_accuracy: 0.7170
Epoch 3/5
239/239 [=====] - 5s 20ms/step - loss: 0.7445 - accuracy: 0.7891 - val_loss: 1.0087 - val_accuracy: 0.7585
Epoch 4/5
239/239 [=====] - 5s 20ms/step - loss: 0.3911 - accuracy: 0.8930 - val_loss: 0.9551 - val_accuracy: 0.7925
Epoch 5/5
239/239 [=====] - 5s 21ms/step - loss: 0.2552 - accuracy: 0.9288 - val_loss: 1.0625 - val_accuracy: 0.8189
[I 2023-12-05 13:50:42,174] Trial 11 finished with value: 0.8188679218292236 and parameters: {'filters_1': 16, 'filters_2': 128, 'units': 256, 'dropout': 0.2037150396158387}. Best is trial 11 with value: 0.8188679218292236.
```

```
Epoch 1/5
239/239 [=====] - 5s 19ms/step - loss: 2.7791 - accuracy: 0.2967 - val_loss: 1.5141 - val_accuracy: 0.5811
Epoch 2/5
239/239 [=====] - 5s 19ms/step - loss: 1.4781 - accuracy: 0.5980 - val_loss: 1.0536 - val_accuracy: 0.7132
Epoch 3/5
239/239 [=====] - 5s 19ms/step - loss: 0.8169 - accuracy: 0.7710 - val_loss: 0.9884 - val_accuracy: 0.7585
Epoch 4/5
239/239 [=====] - 5s 19ms/step - loss: 0.4398 - accuracy: 0.8795 - val_loss: 1.1594 - val_accuracy: 0.7962
Epoch 5/5
239/239 [=====] - 5s 20ms/step - loss: 0.2722 - accuracy: 0.9300 - val_loss: 1.2188 - val_accuracy: 0.7811
[I 2023-12-05 13:51:06,952] Trial 12 finished with value: 0.7811321020126343 and parameters: {'filters_1': 16, 'filters_2': 128, 'units': 256, 'dropout': 0.20151232994550483}. Best is trial 11 with value: 0.8188679218292236.
Epoch 1/5
239/239 [=====] - 5s 19ms/step - loss: 3.3278 - accuracy: 0.1802 - val_loss: 2.0620 - val_accuracy: 0.3925
Epoch 2/5
239/239 [=====] - 4s 18ms/step - loss: 1.9798 - accuracy: 0.4663 - val_loss: 1.2511 - val_accuracy: 0.6604
Epoch 3/5
239/239 [=====] - 5s 19ms/step - loss: 1.2408 - accuracy: 0.6532 - val_loss: 1.0889 - val_accuracy: 0.7208
Epoch 4/5
239/239 [=====] - 5s 21ms/step - loss: 0.7361 - accuracy: 0.7870 - val_loss: 1.0165 - val_accuracy: 0.7736
Epoch 5/5
239/239 [=====] - 4s 18ms/step - loss: 0.4583 - accuracy: 0.8673 - val_loss: 1.1366 - val_accuracy: 0.7660
[I 2023-12-05 13:51:30,743] Trial 13 finished with value: 0.7660377621650696 and parameters: {'filters_1': 16, 'filters_2': 128, 'units': 128, 'dropout': 0.20032059172528738}. Best is trial 11 with value: 0.8188679218292236.
```

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Epoch 1/5
239/239 [=====] - 4s 17ms/step - loss: 2.8997 - accuracy: 0.2514 - val_loss: 1.5499 - val_accuracy: 0.5358
Epoch 2/5
239/239 [=====] - 4s 16ms/step - loss: 1.7673 - accuracy: 0.5140 - val_loss: 1.2140 - val_accuracy: 0.6679
Epoch 3/5
239/239 [=====] - 4s 17ms/step - loss: 1.1439 - accuracy: 0.6810 - val_loss: 0.9438 - val_accuracy: 0.7547
Epoch 4/5
239/239 [=====] - 4s 16ms/step - loss: 0.6798 - accuracy: 0.8084 - val_loss: 1.0522 - val_accuracy: 0.7585
Epoch 5/5
239/239 [=====] - 4s 16ms/step - loss: 0.4295 - accuracy: 0.8763 - val_loss: 0.9584 - val_accuracy: 0.7887
[I 2023-12-05 13:51:51,736] Trial 14 finished with value: 0.7886792421340942 and parameters: {'filters_1': 16, 'filters_2': 32, 'units': 256, 'dropout': 0.2646041133912291}. Best is trial 11 with value: 0.8188679218292236.
Epoch 1/5
239/239 [=====] - 5s 18ms/step - loss: 2.8351 - accuracy: 0.2791 - val_loss: 1.5511 - val_accuracy: 0.5245
Epoch 2/5
239/239 [=====] - 4s 18ms/step - loss: 1.5260 - accuracy: 0.5863 - val_loss: 1.0849 - val_accuracy: 0.7170
Epoch 3/5
239/239 [=====] - 4s 18ms/step - loss: 0.7902 - accuracy: 0.7836 - val_loss: 1.0023 - val_accuracy: 0.7698
Epoch 4/5
239/239 [=====] - 4s 18ms/step - loss: 0.4067 - accuracy: 0.8886 - val_loss: 1.0797 - val_accuracy: 0.8000
Epoch 5/5
239/239 [=====] - 4s 18ms/step - loss: 0.2787 - accuracy: 0.9260 - val_loss: 1.0704 - val_accuracy: 0.7849
[I 2023-12-05 13:52:14,253] Trial 15 finished with value: 0.7849056720733643 and parameters: {'filters_1': 32, 'filters_2': 64, 'units': 256, 'dropout': 0.23308605199605012}. Best is trial 11 with value: 0.8188679218292236.
```

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Epoch 1/5
239/239 [=====] - 5s 19ms/step - loss: 2.9637 - accuracy: 0.2562 - val_loss: 1.5558 - val_accuracy: 0.5774
Epoch 2/5
239/239 [=====] - 5s 19ms/step - loss: 1.7929 - accuracy: 0.5084 - val_loss: 1.1628 - val_accuracy: 0.6491
Epoch 3/5
239/239 [=====] - 5s 18ms/step - loss: 1.2294 - accuracy: 0.6569 - val_loss: 1.0433 - val_accuracy: 0.7094
Epoch 4/5
239/239 [=====] - 5s 19ms/step - loss: 0.8369 - accuracy: 0.7585 - val_loss: 0.9281 - val_accuracy: 0.7472
Epoch 5/5
239/239 [=====] - 5s 19ms/step - loss: 0.5707 - accuracy: 0.8384 - val_loss: 1.0550 - val_accuracy: 0.7472
[I 2023-12-05 13:52:37,909] Trial 16 finished with value: 0.7471697926521301 and parameters: {'filters_1': 16, 'filters_2': 128, 'units': 256, 'dropout': 0.37132744308659577}. Best is trial 11 with value: 0.8188679218292236.
Epoch 1/5
239/239 [=====] - 5s 20ms/step - loss: 3.1694 - accuracy: 0.2049 - val_loss: 1.6469 - val_accuracy: 0.5283
Epoch 2/5
239/239 [=====] - 5s 19ms/step - loss: 1.8106 - accuracy: 0.5046 - val_loss: 1.1797 - val_accuracy: 0.6604
Epoch 3/5
239/239 [=====] - 5s 21ms/step - loss: 1.1143 - accuracy: 0.6889 - val_loss: 1.0500 - val_accuracy: 0.7396
Epoch 4/5
239/239 [=====] - 5s 21ms/step - loss: 0.6648 - accuracy: 0.8101 - val_loss: 1.0685 - val_accuracy: 0.7660
Epoch 5/5
239/239 [=====] - 5s 20ms/step - loss: 0.4348 - accuracy: 0.8733 - val_loss: 1.0460 - val_accuracy: 0.8038
[I 2023-12-05 13:53:03,189] Trial 17 finished with value: 0.8037735819816589 and parameters: {'filters_1': 32, 'filters_2': 128, 'units': 128, 'dropout': 0.2841649030772715}. Best is trial 11 with value: 0.8188679218292236.
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Epoch 1/5
239/239 [=====] - 5s 18ms/step - loss: 2.8259 - accuracy: 0.3081 - val_loss: 1.3539 - val_accuracy: 0.6453
Epoch 2/5
239/239 [=====] - 4s 17ms/step - loss: 1.3846 - accuracy: 0.6344 - val_loss: 1.0480 - val_accuracy: 0.7094
Epoch 3/5
239/239 [=====] - 4s 17ms/step - loss: 0.7170 - accuracy: 0.8021 - val_loss: 1.0618 - val_accuracy: 0.7660
Epoch 4/5
239/239 [=====] - 4s 17ms/step - loss: 0.3826 - accuracy: 0.8961 - val_loss: 1.0263 - val_accuracy: 0.7849
Epoch 5/5
239/239 [=====] - 4s 17ms/step - loss: 0.2313 - accuracy: 0.9382 - val_loss: 1.2418 - val_accuracy: 0.7887
[I 2023-12-05 13:53:25,646] Trial 18 finished with value: 0.7886792421340942 and parameters: {'filters_1': 16, 'filters_2': 64, 'units': 256, 'dropout': 0.22087110391001638}. Best is trial 11 with value: 0.8188679218292236.
Epoch 1/5
239/239 [=====] - 5s 20ms/step - loss: 2.9667 - accuracy: 0.2420 - val_loss: 1.5003 - val_accuracy: 0.5358
Epoch 2/5
239/239 [=====] - 5s 19ms/step - loss: 1.6859 - accuracy: 0.5396 - val_loss: 1.1888 - val_accuracy: 0.6943
Epoch 3/5
239/239 [=====] - 5s 19ms/step - loss: 0.9731 - accuracy: 0.7341 - val_loss: 1.0163 - val_accuracy: 0.7698
Epoch 4/5
239/239 [=====] - 5s 19ms/step - loss: 0.5481 - accuracy: 0.8505 - val_loss: 1.2414 - val_accuracy: 0.7547
Epoch 5/5
239/239 [=====] - 5s 19ms/step - loss: 0.3483 - accuracy: 0.9060 - val_loss: 1.2392 - val_accuracy: 0.7509
[I 2023-12-05 13:53:49,812] Trial 19 finished with value: 0.7509434223175049 and parameters: {'filters_1': 64, 'filters_2': 32, 'units': 256, 'dropout': 0.2829580999747319}. Best is trial 11 with value: 0.8188679218292236.
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Epoch 1/5
239/239 [=====] - 5s 20ms/step - loss: 3.0451 - accuracy: 0.2251 - val_loss: 1.6095 - val_accuracy: 0.5472
Epoch 2/5
239/239 [=====] - 5s 21ms/step - loss: 1.8220 - accuracy: 0.5106 - val_loss: 1.1284 - val_accuracy: 0.6755
Epoch 3/5
239/239 [=====] - 5s 20ms/step - loss: 1.2033 - accuracy: 0.6703 - val_loss: 0.9968 - val_accuracy: 0.7547
Epoch 4/5
239/239 [=====] - 5s 21ms/step - loss: 0.7380 - accuracy: 0.7897 - val_loss: 0.9127 - val_accuracy: 0.7660
Epoch 5/5
239/239 [=====] - 5s 22ms/step - loss: 0.4605 - accuracy: 0.8663 - val_loss: 1.0655 - val_accuracy: 0.7547
[I 2023-12-05 13:54:15,797] Trial 20 finished with value: 0.7547169923782349 and parameters: {'filters_1': 32, 'filters_2': 128, 'units': 128, 'dropout': 0.24082912579267313}. Best is trial 11 with value: 0.8188679218292236.
Epoch 1/5
239/239 [=====] - 6s 22ms/step - loss: 3.0775 - accuracy: 0.2196 - val_loss: 1.7714 - val_accuracy: 0.5208
Epoch 2/5
239/239 [=====] - 5s 20ms/step - loss: 1.9595 - accuracy: 0.4675 - val_loss: 1.1656 - val_accuracy: 0.6868
Epoch 3/5
239/239 [=====] - 5s 21ms/step - loss: 1.4418 - accuracy: 0.5990 - val_loss: 0.9187 - val_accuracy: 0.7396
Epoch 4/5
239/239 [=====] - 5s 21ms/step - loss: 1.0303 - accuracy: 0.7008 - val_loss: 0.8985 - val_accuracy: 0.7774
Epoch 5/5
239/239 [=====] - 5s 22ms/step - loss: 0.7237 - accuracy: 0.7820 - val_loss: 0.9503 - val_accuracy: 0.7736
[I 2023-12-05 13:54:42,142] Trial 21 finished with value: 0.7735849022865295 and parameters: {'filters_1': 32, 'filters_2': 128, 'units': 128, 'dropout': 0.2788171172661818}. Best is trial 11 with value: 0.8188679218292236.
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Epoch 1/5
239/239 [=====] - 5s 21ms/step - loss: 2.9170 - accuracy: 0.2711 - val_loss: 1.5998 - val_accuracy: 0.5585
Epoch 2/5
239/239 [=====] - 5s 19ms/step - loss: 1.6689 - accuracy: 0.5529 - val_loss: 1.1385 - val_accuracy: 0.6943
Epoch 3/5
239/239 [=====] - 5s 20ms/step - loss: 1.0510 - accuracy: 0.7089 - val_loss: 1.1875 - val_accuracy: 0.7396
Epoch 4/5
239/239 [=====] - 5s 21ms/step - loss: 0.6019 - accuracy: 0.8259 - val_loss: 1.2475 - val_accuracy: 0.7509
Epoch 5/5
239/239 [=====] - 5s 20ms/step - loss: 0.3921 - accuracy: 0.8858 - val_loss: 1.2930 - val_accuracy: 0.7434
[I 2023-12-05 13:55:07,803] Trial 22 finished with value: 0.7433962225914001 and parameters: {'filters_1': 32, 'filters_2': 128, 'units': 128, 'dropout': 0.20513871848413887}. Best is trial 11 with value: 0.8188679218292236.
Epoch 1/5
239/239 [=====] - 5s 20ms/step - loss: 2.9187 - accuracy: 0.2610 - val_loss: 1.4942 - val_accuracy: 0.5623
Epoch 2/5
239/239 [=====] - 5s 20ms/step - loss: 1.7467 - accuracy: 0.5344 - val_loss: 1.0710 - val_accuracy: 0.7019
Epoch 3/5
239/239 [=====] - 5s 20ms/step - loss: 1.1377 - accuracy: 0.6826 - val_loss: 0.9722 - val_accuracy: 0.7434
Epoch 4/5
239/239 [=====] - 5s 20ms/step - loss: 0.7093 - accuracy: 0.7959 - val_loss: 1.0520 - val_accuracy: 0.7585
Epoch 5/5
239/239 [=====] - 5s 19ms/step - loss: 0.4603 - accuracy: 0.8624 - val_loss: 0.9713 - val_accuracy: 0.7660
[I 2023-12-05 13:55:32,914] Trial 23 finished with value: 0.7660377621650696 and parameters: {'filters_1': 32, 'filters_2': 128, 'units': 128, 'dropout': 0.2390473763092657}. Best is trial 11 with value: 0.8188679218292236.
```

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Epoch 1/5
239/239 [=====] - 5s 20ms/step - loss: 2.9520 - accuracy: 0.2509 - val_loss: 1.5286 - val_accuracy: 0.5698
Epoch 2/5
239/239 [=====] - 5s 20ms/step - loss: 1.7506 - accuracy: 0.5302 - val_loss: 0.9722 - val_accuracy: 0.7283
Epoch 3/5
239/239 [=====] - 5s 20ms/step - loss: 1.0928 - accuracy: 0.6971 - val_loss: 0.8017 - val_accuracy: 0.7509
Epoch 4/5
239/239 [=====] - 5s 20ms/step - loss: 0.6742 - accuracy: 0.8065 - val_loss: 0.7970 - val_accuracy: 0.7811
Epoch 5/5
239/239 [=====] - 5s 20ms/step - loss: 0.4416 - accuracy: 0.8719 - val_loss: 0.8008 - val_accuracy: 0.7887
[I 2023-12-05 13:55:58,190] Trial 24 finished with value: 0.7886792421340942 and parameters: {'filters_1': 32, 'filters_2': 128, 'units': 128, 'dropout': 0.2927700114808126}. Best is trial 11 with value: 0.8188679218292236.
Epoch 1/5
239/239 [=====] - 5s 19ms/step - loss: 2.8011 - accuracy: 0.2844 - val_loss: 1.4578 - val_accuracy: 0.5849
Epoch 2/5
239/239 [=====] - 5s 19ms/step - loss: 1.6488 - accuracy: 0.5518 - val_loss: 1.0751 - val_accuracy: 0.7170
Epoch 3/5
239/239 [=====] - 5s 19ms/step - loss: 0.9847 - accuracy: 0.7280 - val_loss: 1.0426 - val_accuracy: 0.7623
Epoch 4/5
239/239 [=====] - 5s 19ms/step - loss: 0.5508 - accuracy: 0.8461 - val_loss: 1.1772 - val_accuracy: 0.7660
Epoch 5/5
239/239 [=====] - 5s 20ms/step - loss: 0.3345 - accuracy: 0.9066 - val_loss: 1.1183 - val_accuracy: 0.7849
[I 2023-12-05 13:56:22,360] Trial 25 finished with value: 0.7849056720733643 and parameters: {'filters_1': 16, 'filters_2': 128, 'units': 256, 'dropout': 0.2569739814966788}. Best is trial 11 with value: 0.8188679218292236.
```

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Epoch 1/5
239/239 [=====] - 5s 20ms/step - loss: 2.9154 - accuracy: 0.2667 - val_loss: 1.5594 - val_accuracy: 0.5509
Epoch 2/5
239/239 [=====] - 5s 20ms/step - loss: 1.7690 - accuracy: 0.5214 - val_loss: 1.2258 - val_accuracy: 0.6453
Epoch 3/5
239/239 [=====] - 5s 20ms/step - loss: 1.1310 - accuracy: 0.6814 - val_loss: 1.0259 - val_accuracy: 0.7509
Epoch 4/5
239/239 [=====] - 5s 20ms/step - loss: 0.7036 - accuracy: 0.7985 - val_loss: 1.0755 - val_accuracy: 0.7472
Epoch 5/5
239/239 [=====] - 5s 21ms/step - loss: 0.4512 - accuracy: 0.8730 - val_loss: 1.1434 - val_accuracy: 0.7736
[I 2023-12-05 13:56:47,685] Trial 26 finished with value: 0.7735849022865295 and parameters: {'filters_1': 32, 'filters_2': 128, 'units': 128, 'dropout': 0.22333183813630642}. Best is trial 11 with value: 0.8188679218292236.
Epoch 1/5
239/239 [=====] - 5s 21ms/step - loss: 2.7954 - accuracy: 0.2907 - val_loss: 1.6139 - val_accuracy: 0.5623
Epoch 2/5
239/239 [=====] - 5s 20ms/step - loss: 1.5747 - accuracy: 0.5670 - val_loss: 1.0658 - val_accuracy: 0.6906
Epoch 3/5
239/239 [=====] - 5s 20ms/step - loss: 0.8591 - accuracy: 0.7611 - val_loss: 1.1002 - val_accuracy: 0.7057
Epoch 4/5
239/239 [=====] - 5s 20ms/step - loss: 0.4837 - accuracy: 0.8639 - val_loss: 0.9504 - val_accuracy: 0.7849
Epoch 5/5
239/239 [=====] - 5s 20ms/step - loss: 0.2770 - accuracy: 0.9225 - val_loss: 1.0605 - val_accuracy: 0.7774
[I 2023-12-05 13:57:13,155] Trial 27 finished with value: 0.7773584723472595 and parameters: {'filters_1': 32, 'filters_2': 128, 'units': 256, 'dropout': 0.291355198444666}. Best is trial 11 with value: 0.8188679218292236.
```

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Epoch 1/5
239/239 [=====] - 5s 20ms/step - loss: 3.0420 - accuracy: 0.2256 - val_loss: 1.7196 - val_accuracy: 0.4981
Epoch 2/5
239/239 [=====] - 5s 20ms/step - loss: 1.8424 - accuracy: 0.5037 - val_loss: 1.1243 - val_accuracy: 0.6830
Epoch 3/5
239/239 [=====] - 5s 20ms/step - loss: 1.2090 - accuracy: 0.6623 - val_loss: 0.9662 - val_accuracy: 0.7245
Epoch 4/5
239/239 [=====] - 5s 21ms/step - loss: 0.7452 - accuracy: 0.7896 - val_loss: 1.1690 - val_accuracy: 0.7623
Epoch 5/5
239/239 [=====] - 5s 20ms/step - loss: 0.4897 - accuracy: 0.8590 - val_loss: 1.1219 - val_accuracy: 0.7774
[I 2023-12-05 13:57:38,303] Trial 28 finished with value: 0.7773584723472595 and parameters: {'filters_1': 64, 'filters_2': 64, 'units': 128, 'dropout': 0.2518516177037227}. Best is trial 11 with value: 0.8188679218292236.
Epoch 1/5
239/239 [=====] - 4s 17ms/step - loss: 2.7968 - accuracy: 0.2886 - val_loss: 1.4506 - val_accuracy: 0.5925
Epoch 2/5
239/239 [=====] - 4s 16ms/step - loss: 1.4892 - accuracy: 0.6003 - val_loss: 1.0982 - val_accuracy: 0.6755
Epoch 3/5
239/239 [=====] - 4s 16ms/step - loss: 0.8175 - accuracy: 0.7710 - val_loss: 1.0821 - val_accuracy: 0.7208
Epoch 4/5
239/239 [=====] - 4s 16ms/step - loss: 0.4276 - accuracy: 0.8820 - val_loss: 1.1935 - val_accuracy: 0.7132
Epoch 5/5
239/239 [=====] - 4s 16ms/step - loss: 0.2826 - accuracy: 0.9229 - val_loss: 1.3539 - val_accuracy: 0.7585
[I 2023-12-05 13:57:58,718] Trial 29 finished with value: 0.7584905624389648 and parameters: {'filters_1': 16, 'filters_2': 32, 'units': 256, 'dropout': 0.21761686011902373}. Best is trial 11 with value: 0.8188679218292236.
```

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Epoch 1/5
239/239 [=====] - 5s 21ms/step - loss: 2.9979 - accuracy: 0.2441 - val_loss: 1.6091 - val_accuracy: 0.5623
Epoch 2/5
239/239 [=====] - 5s 21ms/step - loss: 1.8662 - accuracy: 0.4912 - val_loss: 1.1062 - val_accuracy: 0.6943
Epoch 3/5
239/239 [=====] - 5s 20ms/step - loss: 1.3025 - accuracy: 0.6388 - val_loss: 0.9118 - val_accuracy: 0.7509
Epoch 4/5
239/239 [=====] - 5s 20ms/step - loss: 0.8964 - accuracy: 0.7491 - val_loss: 0.8089 - val_accuracy: 0.7660
Epoch 5/5
239/239 [=====] - 5s 20ms/step - loss: 0.6284 - accuracy: 0.8194 - val_loss: 0.9089 - val_accuracy: 0.7887
[I 2023-12-05 13:58:29,452] Trial 30 finished with value: 0.7886792421340942 and parameters: {'filters_1': 32, 'filters_2': 128, 'units': 256, 'dropout': 0.4923111946277203}. Best is trial 11 with value: 0.8188679218292236.
Epoch 1/5
239/239 [=====] - 5s 19ms/step - loss: 2.9235 - accuracy: 0.2651 - val_loss: 1.4263 - val_accuracy: 0.6453
Epoch 2/5
239/239 [=====] - 5s 18ms/step - loss: 1.4781 - accuracy: 0.6028 - val_loss: 0.9357 - val_accuracy: 0.7170
Epoch 3/5
239/239 [=====] - 4s 18ms/step - loss: 0.8289 - accuracy: 0.7733 - val_loss: 0.9925 - val_accuracy: 0.7774
Epoch 4/5
239/239 [=====] - 5s 19ms/step - loss: 0.4747 - accuracy: 0.8692 - val_loss: 1.1386 - val_accuracy: 0.7623
Epoch 5/5
239/239 [=====] - 5s 19ms/step - loss: 0.3139 - accuracy: 0.9168 - val_loss: 1.0806 - val_accuracy: 0.7849
[I 2023-12-05 13:58:53,290] Trial 31 finished with value: 0.7849056720733643 and parameters: {'filters_1': 16, 'filters_2': 128, 'units': 256, 'dropout': 0.2662955612619326}. Best is trial 11 with value: 0.8188679218292236.
```

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Epoch 1/5
239/239 [=====] - 5s 19ms/step - loss: 2.8786 - accuracy: 0.2854 - val_loss: 1.3433 - val_accuracy: 0.6264
Epoch 2/5
239/239 [=====] - 5s 19ms/step - loss: 1.4684 - accuracy: 0.6118 - val_loss: 1.0760 - val_accuracy: 0.6981
Epoch 3/5
239/239 [=====] - 4s 18ms/step - loss: 0.7845 - accuracy: 0.7831 - val_loss: 1.1313 - val_accuracy: 0.7321
Epoch 4/5
239/239 [=====] - 5s 19ms/step - loss: 0.4176 - accuracy: 0.8843 - val_loss: 1.1799 - val_accuracy: 0.7698
Epoch 5/5
239/239 [=====] - 5s 19ms/step - loss: 0.2617 - accuracy: 0.9294 - val_loss: 1.1944 - val_accuracy: 0.7698
[I 2023-12-05 13:59:16,880] Trial 32 finished with value: 0.7698113322257996 and parameters: {'filters_1': 16, 'filters_2': 128, 'units': 256, 'dropout': 0.22710360100313493}. Best is trial 11 with value: 0.8188679218292236.
Epoch 1/5
239/239 [=====] - 5s 20ms/step - loss: 2.9203 - accuracy: 0.2743 - val_loss: 1.6419 - val_accuracy: 0.5849
Epoch 2/5
239/239 [=====] - 4s 18ms/step - loss: 1.5032 - accuracy: 0.5952 - val_loss: 1.1058 - val_accuracy: 0.7170
Epoch 3/5
239/239 [=====] - 4s 18ms/step - loss: 0.8434 - accuracy: 0.7731 - val_loss: 1.1463 - val_accuracy: 0.7321
Epoch 4/5
239/239 [=====] - 5s 19ms/step - loss: 0.4952 - accuracy: 0.8656 - val_loss: 1.2322 - val_accuracy: 0.7547
Epoch 5/5
239/239 [=====] - 5s 19ms/step - loss: 0.3086 - accuracy: 0.9154 - val_loss: 1.4944 - val_accuracy: 0.7358
[I 2023-12-05 13:59:40,198] Trial 33 finished with value: 0.7358490824699402 and parameters: {'filters_1': 16, 'filters_2': 128, 'units': 256, 'dropout': 0.2466607575322461}. Best is trial 11 with value: 0.8188679218292236.
```

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Epoch 1/5
239/239 [=====] - 5s 20ms/step - loss: 2.6953 - accuracy: 0.3217 - val_loss: 1.3572 - val_accuracy: 0.6189
Epoch 2/5
239/239 [=====] - 5s 19ms/step - loss: 1.4542 - accuracy: 0.6118 - val_loss: 1.0272 - val_accuracy: 0.7245
Epoch 3/5
239/239 [=====] - 5s 20ms/step - loss: 0.7340 - accuracy: 0.7975 - val_loss: 1.2515 - val_accuracy: 0.7283
Epoch 4/5
239/239 [=====] - 5s 19ms/step - loss: 0.3746 - accuracy: 0.8976 - val_loss: 1.0120 - val_accuracy: 0.7623
Epoch 5/5
239/239 [=====] - 5s 20ms/step - loss: 0.2271 - accuracy: 0.9420 - val_loss: 0.9216 - val_accuracy: 0.7623
[I 2023-12-05 14:00:04,514] Trial 34 finished with value: 0.7622641324996948 and parameters: {'filters_1': 16, 'filters_2': 128, 'units': 256, 'dropout': 0.23892062584656948}. Best is trial 11 with value: 0.8188679218292236.
Epoch 1/5
239/239 [=====] - 6s 23ms/step - loss: 3.2560 - accuracy: 0.1817 - val_loss: 1.7639 - val_accuracy: 0.4830
Epoch 2/5
239/239 [=====] - 5s 22ms/step - loss: 1.9897 - accuracy: 0.4589 - val_loss: 1.3167 - val_accuracy: 0.6226
Epoch 3/5
239/239 [=====] - 6s 23ms/step - loss: 1.3753 - accuracy: 0.6177 - val_loss: 1.2460 - val_accuracy: 0.6566
Epoch 4/5
239/239 [=====] - 6s 23ms/step - loss: 0.9940 - accuracy: 0.7110 - val_loss: 1.2887 - val_accuracy: 0.6943
Epoch 5/5
239/239 [=====] - 6s 23ms/step - loss: 0.7495 - accuracy: 0.7855 - val_loss: 1.1909 - val_accuracy: 0.7208
[I 2023-12-05 14:00:33,204] Trial 35 finished with value: 0.7207547426223755 and parameters: {'filters_1': 64, 'filters_2': 128, 'units': 64, 'dropout': 0.21856247094776776}. Best is trial 11 with value: 0.8188679218292236.
```

```
Epoch 1/5
239/239 [=====] - 5s 21ms/step - loss: 2.9086 - accuracy: 0.2665 - val_loss: 1.4751 - val_accuracy: 0.6075
Epoch 2/5
239/239 [=====] - 5s 20ms/step - loss: 1.6507 - accuracy: 0.5610 - val_loss: 0.9798 - val_accuracy: 0.7019
Epoch 3/5
239/239 [=====] - 5s 21ms/step - loss: 0.9561 - accuracy: 0.7392 - val_loss: 0.7494 - val_accuracy: 0.8000
Epoch 4/5
239/239 [=====] - 5s 21ms/step - loss: 0.5144 - accuracy: 0.8606 - val_loss: 0.6934 - val_accuracy: 0.8377
Epoch 5/5
239/239 [=====] - 5s 20ms/step - loss: 0.3306 - accuracy: 0.9126 - val_loss: 0.8814 - val_accuracy: 0.8189
[I 2023-12-05 14:00:58,515] Trial 36 finished with value: 0.8188679218292236 and parameters: {'filters_1': 32, 'filters_2': 128, 'units': 256, 'dropout': 0.33958362695028715}. Best is trial 11 with value: 0.8188679218292236.
Epoch 1/5
239/239 [=====] - 5s 21ms/step - loss: 3.1088 - accuracy: 0.2175 - val_loss: 1.5521 - val_accuracy: 0.5698
Epoch 2/5
239/239 [=====] - 5s 20ms/step - loss: 1.7019 - accuracy: 0.5338 - val_loss: 1.0241 - val_accuracy: 0.6868
Epoch 3/5
239/239 [=====] - 5s 20ms/step - loss: 0.9937 - accuracy: 0.7260 - val_loss: 0.8519 - val_accuracy: 0.7472
Epoch 4/5
239/239 [=====] - 5s 20ms/step - loss: 0.5490 - accuracy: 0.8461 - val_loss: 0.7540 - val_accuracy: 0.7849
Epoch 5/5
239/239 [=====] - 5s 20ms/step - loss: 0.3297 - accuracy: 0.9104 - val_loss: 0.7849 - val_accuracy: 0.7887
[I 2023-12-05 14:01:23,650] Trial 37 finished with value: 0.7886792421340942 and parameters: {'filters_1': 32, 'filters_2': 128, 'units': 256, 'dropout': 0.35387366525229874}. Best is trial 11 with value: 0.8188679218292236.
```

```
Epoch 1/5
239/239 [=====] - 5s 17ms/step - loss: 3.4045 - accuracy: 0.1438 - val_loss: 2.0360 - val_accuracy: 0.4302
Epoch 2/5
239/239 [=====] - 4s 17ms/step - loss: 2.2894 - accuracy: 0.3817 - val_loss: 1.3186 - val_accuracy: 0.6415
Epoch 3/5
239/239 [=====] - 4s 17ms/step - loss: 1.7224 - accuracy: 0.5223 - val_loss: 1.0352 - val_accuracy: 0.7245
Epoch 4/5
239/239 [=====] - 4s 18ms/step - loss: 1.3160 - accuracy: 0.6238 - val_loss: 0.8610 - val_accuracy: 0.7547
Epoch 5/5
239/239 [=====] - 4s 17ms/step - loss: 1.0390 - accuracy: 0.6866 - val_loss: 0.8853 - val_accuracy: 0.7660
[I 2023-12-05 14:01:45,374] Trial 38 finished with value: 0.7660377621650696 and parameters: {'filters_1': 32, 'filters_2': 64, 'units': 64, 'dropout': 0.3382968737806058}. Best is trial 11 with value: 0.8188679218292236.
Epoch 1/5
239/239 [=====] - 5s 21ms/step - loss: 2.8920 - accuracy: 0.2710 - val_loss: 1.5111 - val_accuracy: 0.5811
Epoch 2/5
239/239 [=====] - 5s 20ms/step - loss: 1.6161 - accuracy: 0.5690 - val_loss: 1.1387 - val_accuracy: 0.6868
Epoch 3/5
239/239 [=====] - 5s 20ms/step - loss: 0.9638 - accuracy: 0.7368 - val_loss: 1.1008 - val_accuracy: 0.7208
Epoch 4/5
239/239 [=====] - 5s 20ms/step - loss: 0.5734 - accuracy: 0.8383 - val_loss: 1.3726 - val_accuracy: 0.7170
Epoch 5/5
239/239 [=====] - 5s 20ms/step - loss: 0.3676 - accuracy: 0.9010 - val_loss: 1.3783 - val_accuracy: 0.7660
[I 2023-12-05 14:02:10,434] Trial 39 finished with value: 0.7660377621650696 and parameters: {'filters_1': 32, 'filters_2': 128, 'units': 256, 'dropout': 0.30598132834570696}. Best is trial 11 with value: 0.8188679218292236.
```

```
Epoch 1/5
239/239 [=====] - 5s 20ms/step - loss: 3.3389 - accuracy: 0.1699 - val_loss: 1.8898 - val_accuracy: 0.5094
Epoch 2/5
239/239 [=====] - 5s 20ms/step - loss: 2.1038 - accuracy: 0.4368 - val_loss: 1.2854 - val_accuracy: 0.6604
Epoch 3/5
239/239 [=====] - 5s 20ms/step - loss: 1.5514 - accuracy: 0.5653 - val_loss: 1.0772 - val_accuracy: 0.7132
Epoch 4/5
239/239 [=====] - 5s 20ms/step - loss: 1.1596 - accuracy: 0.6588 - val_loss: 1.0638 - val_accuracy: 0.7283
Epoch 5/5
239/239 [=====] - 5s 19ms/step - loss: 0.9146 - accuracy: 0.7294 - val_loss: 1.0889 - val_accuracy: 0.7660
[I 2023-12-05 14:02:35,080] Trial 40 finished with value: 0.7660377621650696 and parameters: {'filters_1': 32, 'filters_2': 128, 'units': 64, 'dropout': 0.2736312877789945}. Best is trial 11 with value: 0.8188679218292236.
Epoch 1/5
239/239 [=====] - 5s 21ms/step - loss: 3.1942 - accuracy: 0.1958 - val_loss: 1.8391 - val_accuracy: 0.5057
Epoch 2/5
239/239 [=====] - 5s 20ms/step - loss: 1.7779 - accuracy: 0.5184 - val_loss: 1.1635 - val_accuracy: 0.6792
Epoch 3/5
239/239 [=====] - 5s 20ms/step - loss: 1.0175 - accuracy: 0.7193 - val_loss: 0.8965 - val_accuracy: 0.7585
Epoch 4/5
239/239 [=====] - 5s 21ms/step - loss: 0.5614 - accuracy: 0.8439 - val_loss: 0.8861 - val_accuracy: 0.7962
Epoch 5/5
239/239 [=====] - 5s 20ms/step - loss: 0.3040 - accuracy: 0.9146 - val_loss: 1.0138 - val_accuracy: 0.7623
[I 2023-12-05 14:03:00,941] Trial 41 finished with value: 0.7622641324996948 and parameters: {'filters_1': 32, 'filters_2': 128, 'units': 256, 'dropout': 0.2543376909804258}. Best is trial 11 with value: 0.8188679218292236.
```

```
Epoch 1/5
239/239 [=====] - 5s 19ms/step - loss: 2.8481 - accuracy: 0.2778 - val_loss: 1.4498 - val_accuracy: 0.5811
Epoch 2/5
239/239 [=====] - 5s 19ms/step - loss: 1.5775 - accuracy: 0.5797 - val_loss: 1.0879 - val_accuracy: 0.6868
Epoch 3/5
239/239 [=====] - 5s 20ms/step - loss: 0.8877 - accuracy: 0.7542 - val_loss: 1.0274 - val_accuracy: 0.7472
Epoch 4/5
239/239 [=====] - 5s 20ms/step - loss: 0.5007 - accuracy: 0.8576 - val_loss: 1.1559 - val_accuracy: 0.7472
Epoch 5/5
239/239 [=====] - 5s 19ms/step - loss: 0.3190 - accuracy: 0.9128 - val_loss: 1.1261 - val_accuracy: 0.7774
[I 2023-12-05 14:03:25,129] Trial 42 finished with value: 0.7773584723472595 and parameters: {'filters_1': 16, 'filters_2': 128, 'units': 256, 'dropout': 0.3077622879182404}. Best is trial 11 with value: 0.8188679218292236.
Epoch 1/5
239/239 [=====] - 5s 20ms/step - loss: 2.7959 - accuracy: 0.2994 - val_loss: 1.3527 - val_accuracy: 0.6151
Epoch 2/5
239/239 [=====] - 5s 20ms/step - loss: 1.5120 - accuracy: 0.5946 - val_loss: 1.0739 - val_accuracy: 0.7094
Epoch 3/5
239/239 [=====] - 5s 20ms/step - loss: 0.8824 - accuracy: 0.7585 - val_loss: 1.0308 - val_accuracy: 0.7698
Epoch 4/5
239/239 [=====] - 5s 20ms/step - loss: 0.4851 - accuracy: 0.8658 - val_loss: 1.1468 - val_accuracy: 0.7736
Epoch 5/5
239/239 [=====] - 5s 21ms/step - loss: 0.3206 - accuracy: 0.9132 - val_loss: 1.1152 - val_accuracy: 0.7849
[I 2023-12-05 14:03:50,359] Trial 43 finished with value: 0.7849056720733643 and parameters: {'filters_1': 32, 'filters_2': 128, 'units': 256, 'dropout': 0.26949685504495374}. Best is trial 11 with value: 0.8188679218292236.
```

```
Epoch 1/5
239/239 [=====] - 5s 19ms/step - loss: 2.8333 - accuracy: 0.2792 - val_loss: 1.5005 - val_accuracy: 0.5887
Epoch 2/5
239/239 [=====] - 5s 19ms/step - loss: 1.6244 - accuracy: 0.5655 - val_loss: 1.0832 - val_accuracy: 0.7208
Epoch 3/5
239/239 [=====] - 5s 20ms/step - loss: 0.9383 - accuracy: 0.7373 - val_loss: 1.0347 - val_accuracy: 0.7434
Epoch 4/5
239/239 [=====] - 5s 20ms/step - loss: 0.5473 - accuracy: 0.8463 - val_loss: 1.0664 - val_accuracy: 0.7623
Epoch 5/5
239/239 [=====] - 5s 20ms/step - loss: 0.3409 - accuracy: 0.9019 - val_loss: 1.2307 - val_accuracy: 0.7849
[I 2023-12-05 14:04:15,205] Trial 44 finished with value: 0.7849056720733643 and parameters: {'filters_1': 64, 'filters_2': 32, 'units': 256, 'dropout': 0.3234901531046746}. Best is trial 11 with value: 0.8188679218292236.
Epoch 1/5
239/239 [=====] - 5s 18ms/step - loss: 2.8406 - accuracy: 0.2803 - val_loss: 1.4278 - val_accuracy: 0.5660
Epoch 2/5
239/239 [=====] - 5s 19ms/step - loss: 1.5168 - accuracy: 0.5925 - val_loss: 1.0360 - val_accuracy: 0.6906
Epoch 3/5
239/239 [=====] - 5s 19ms/step - loss: 0.8494 - accuracy: 0.7668 - val_loss: 1.0008 - val_accuracy: 0.7396
Epoch 4/5
239/239 [=====] - 4s 18ms/step - loss: 0.4534 - accuracy: 0.8716 - val_loss: 1.0109 - val_accuracy: 0.7849
Epoch 5/5
239/239 [=====] - 5s 19ms/step - loss: 0.2874 - accuracy: 0.9226 - val_loss: 1.1535 - val_accuracy: 0.7925
[I 2023-12-05 14:04:38,798] Trial 45 finished with value: 0.7924528121948242 and parameters: {'filters_1': 16, 'filters_2': 128, 'units': 256, 'dropout': 0.21082288479449154}. Best is trial 11 with value: 0.8188679218292236.
```

```
Epoch 1/5
239/239 [=====] - 5s 20ms/step - loss: 2.9418 - accuracy: 0.2581 - val_loss: 1.5931 - val_accuracy: 0.5509
Epoch 2/5
239/239 [=====] - 5s 20ms/step - loss: 1.7334 - accuracy: 0.5373 - val_loss: 1.1842 - val_accuracy: 0.6981
Epoch 3/5
239/239 [=====] - 5s 21ms/step - loss: 1.0689 - accuracy: 0.7040 - val_loss: 0.9416 - val_accuracy: 0.7736
Epoch 4/5
239/239 [=====] - 5s 21ms/step - loss: 0.6337 - accuracy: 0.8183 - val_loss: 1.1802 - val_accuracy: 0.7585
Epoch 5/5
239/239 [=====] - 5s 21ms/step - loss: 0.4439 - accuracy: 0.8703 - val_loss: 1.0473 - val_accuracy: 0.7962
[I 2023-12-05 14:05:04,530] Trial 46 finished with value: 0.796226441860199 and parameters: {'filters_1': 32, 'filters_2': 128, 'units': 128, 'dropout': 0.23406556038040907}. Best is trial 11 with value: 0.8188679218292236.
Epoch 1/5
239/239 [=====] - 5s 20ms/step - loss: 2.8652 - accuracy: 0.2807 - val_loss: 1.5986 - val_accuracy: 0.5358
Epoch 2/5
239/239 [=====] - 5s 19ms/step - loss: 1.6614 - accuracy: 0.5595 - val_loss: 1.2505 - val_accuracy: 0.6453
Epoch 3/5
239/239 [=====] - 5s 19ms/step - loss: 1.0054 - accuracy: 0.7219 - val_loss: 1.1319 - val_accuracy: 0.7208
Epoch 4/5
239/239 [=====] - 5s 20ms/step - loss: 0.6167 - accuracy: 0.8220 - val_loss: 1.2014 - val_accuracy: 0.7623
Epoch 5/5
239/239 [=====] - 5s 19ms/step - loss: 0.3929 - accuracy: 0.8944 - val_loss: 1.2975 - val_accuracy: 0.7472
[I 2023-12-05 14:05:28,773] Trial 47 finished with value: 0.7471697926521301 and parameters: {'filters_1': 32, 'filters_2': 128, 'units': 128, 'dropout': 0.20146691079906387}. Best is trial 11 with value: 0.8188679218292236.
```

```
Epoch 1/5
239/239 [=====] - 5s 18ms/step - loss: 2.9862 - accuracy: 0.2488 - val_loss: 1.6130 - val_accuracy: 0.5321
Epoch 2/5
239/239 [=====] - 4s 17ms/step - loss: 1.7814 - accuracy: 0.5171 - val_loss: 1.1511 - val_accuracy: 0.6604
Epoch 3/5
239/239 [=====] - 4s 18ms/step - loss: 1.1456 - accuracy: 0.6861 - val_loss: 0.9134 - val_accuracy: 0.7208
Epoch 4/5
239/239 [=====] - 4s 17ms/step - loss: 0.7420 - accuracy: 0.7870 - val_loss: 1.0128 - val_accuracy: 0.7434
Epoch 5/5
239/239 [=====] - 4s 16ms/step - loss: 0.4979 - accuracy: 0.8526 - val_loss: 1.0339 - val_accuracy: 0.7774
[I 2023-12-05 14:05:50,449] Trial 48 finished with value: 0.7773584723472595 and parameters: {'filters_1': 32, 'filters_2': 64, 'units': 128, 'dropout': 0.22587246942945716}. Best is trial 11 with value: 0.8188679218292236.
Epoch 1/5
239/239 [=====] - 5s 20ms/step - loss: 2.8940 - accuracy: 0.2777 - val_loss: 1.5164 - val_accuracy: 0.5736
Epoch 2/5
239/239 [=====] - 5s 19ms/step - loss: 1.6940 - accuracy: 0.5463 - val_loss: 0.9759 - val_accuracy: 0.7132
Epoch 3/5
239/239 [=====] - 5s 20ms/step - loss: 1.0819 - accuracy: 0.7008 - val_loss: 0.9223 - val_accuracy: 0.7472
Epoch 4/5
239/239 [=====] - 5s 20ms/step - loss: 0.6648 - accuracy: 0.8130 - val_loss: 1.0518 - val_accuracy: 0.7472
Epoch 5/5
239/239 [=====] - 5s 19ms/step - loss: 0.4301 - accuracy: 0.8705 - val_loss: 0.9599 - val_accuracy: 0.7811
[I 2023-12-05 14:06:14,963] Trial 49 finished with value: 0.7811321020126343 and parameters: {'filters_1': 32, 'filters_2': 128, 'units': 128, 'dropout': 0.23960013585888143}. Best is trial 11 with value: 0.8188679218292236.
Best trial: {'filters_1': 16, 'filters_2': 128, 'units': 256, 'dropout': 0.2037150396158387}
```

Let's run the model with our best hyperparameters

```
In [15]: filters_1 = 16
filters_2 = 128
```

```
units = 256
dropout = 0.2037150396158387

model_bhp = Sequential([
    layers.Rescaling(1./255, input_shape=(224, 224, 3)), # If we don't rescale, we get TERRIBLE accuracy. Worth looking into.
    layers.Conv2D(filters_1, 3, padding='same', activation='relu'),
    layers.MaxPooling2D(),
    layers.Conv2D(filters_2, 3, padding='same', activation='relu'),
    layers.MaxPooling2D(),
    layers.Conv2D(filters_2, 3, padding='same', activation='relu'),
    layers.MaxPooling2D(),
    layers.Dropout(dropout),
    layers.Flatten(),
    layers.Dense(units, activation='relu'),
    layers.Dense(num_classes) # this line MUST correspond to the number of classes/Labels, else it crashes
])
```

```
In [16]: model_bhp.compile(optimizer='adam',
    loss=tf.keras.losses.SparseCategoricalCrossentropy(from_logits=True),
    metrics=['accuracy'])
```

```
In [17]: # Train the model
epochs = 20
history_bhp = model_bhp.fit(
    train_ds,
    validation_data=val_ds,
    epochs=epochs
)
```

Epoch 1/20
239/239 [=====] - 7s 21ms/step - loss: 2.6764 - accuracy: 0.3269 - val_loss: 1.5215 - val_accuracy: 0.5509
Epoch 2/20
239/239 [=====] - 5s 20ms/step - loss: 1.4459 - accuracy: 0.6110 - val_loss: 1.0431 - val_accuracy: 0.7132
Epoch 3/20
239/239 [=====] - 5s 19ms/step - loss: 0.7119 - accuracy: 0.8044 - val_loss: 1.0780 - val_accuracy: 0.7623
Epoch 4/20
239/239 [=====] - 5s 19ms/step - loss: 0.3516 - accuracy: 0.9084 - val_loss: 1.1418 - val_accuracy: 0.7509
Epoch 5/20
239/239 [=====] - 5s 19ms/step - loss: 0.1868 - accuracy: 0.9546 - val_loss: 1.0350 - val_accuracy: 0.8038
Epoch 6/20
239/239 [=====] - 5s 19ms/step - loss: 0.1181 - accuracy: 0.9701 - val_loss: 1.2223 - val_accuracy: 0.7811
Epoch 7/20
239/239 [=====] - 5s 19ms/step - loss: 0.1067 - accuracy: 0.9765 - val_loss: 1.3070 - val_accuracy: 0.7623
Epoch 8/20
239/239 [=====] - 5s 19ms/step - loss: 0.0754 - accuracy: 0.9820 - val_loss: 1.1631 - val_accuracy: 0.8000
Epoch 9/20
239/239 [=====] - 5s 19ms/step - loss: 0.0853 - accuracy: 0.9805 - val_loss: 1.1871 - val_accuracy: 0.8113
Epoch 10/20
239/239 [=====] - 5s 19ms/step - loss: 0.0614 - accuracy: 0.9853 - val_loss: 1.2397 - val_accuracy: 0.8151
Epoch 11/20
239/239 [=====] - 5s 20ms/step - loss: 0.0790 - accuracy: 0.9860 - val_loss: 1.1905 - val_accuracy: 0.8113
Epoch 12/20
239/239 [=====] - 5s 19ms/step - loss: 0.0599 - accuracy: 0.9856 - val_loss: 1.3798 - val_accuracy: 0.8264
Epoch 13/20
239/239 [=====] - 5s 19ms/step - loss: 0.0411 - accuracy: 0.9899 - val_loss: 1.2025 - val_accuracy: 0.8415
Epoch 14/20
239/239 [=====] - 5s 19ms/step - loss: 0.0479 - accuracy: 0.9894 - val_loss: 1.0937 - val_accuracy: 0.8038

```
Epoch 15/20
239/239 [=====] - 5s 19ms/step - loss: 0.0510 - accuracy: 0.9895 - val_loss: 1.1694 - val_accuracy: 0.7962
Epoch 16/20
239/239 [=====] - 5s 19ms/step - loss: 0.0507 - accuracy: 0.9896 - val_loss: 1.4490 - val_accuracy: 0.7925
Epoch 17/20
239/239 [=====] - 5s 19ms/step - loss: 0.0390 - accuracy: 0.9906 - val_loss: 1.1727 - val_accuracy: 0.8226
Epoch 18/20
239/239 [=====] - 5s 20ms/step - loss: 0.0303 - accuracy: 0.9930 - val_loss: 1.2872 - val_accuracy: 0.8453
Epoch 19/20
239/239 [=====] - 5s 19ms/step - loss: 0.0511 - accuracy: 0.9900 - val_loss: 1.2235 - val_accuracy: 0.8453
Epoch 20/20
239/239 [=====] - 5s 19ms/step - loss: 0.0503 - accuracy: 0.9891 - val_loss: 1.3044 - val_accuracy: 0.8415
```

```
In [18]: acc = history_bhp.history['accuracy']
val_acc = history_bhp.history['val_accuracy']

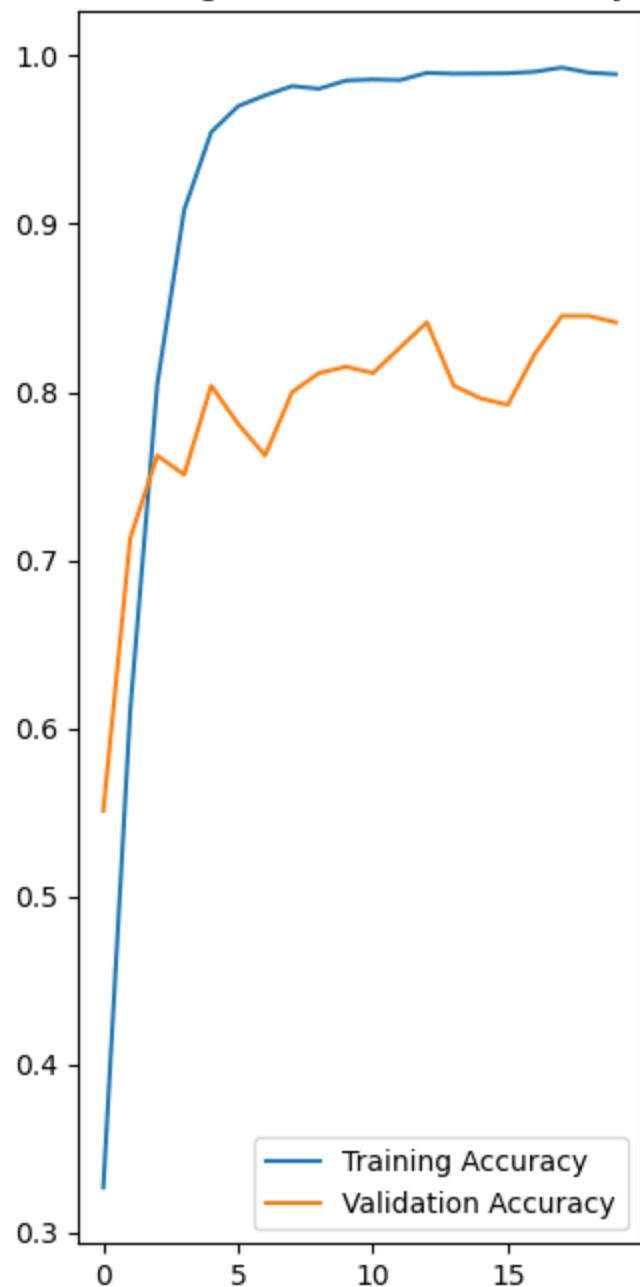
loss = history_bhp.history['loss']
val_loss = history_bhp.history['val_loss']

epochs_range = range(epochs)

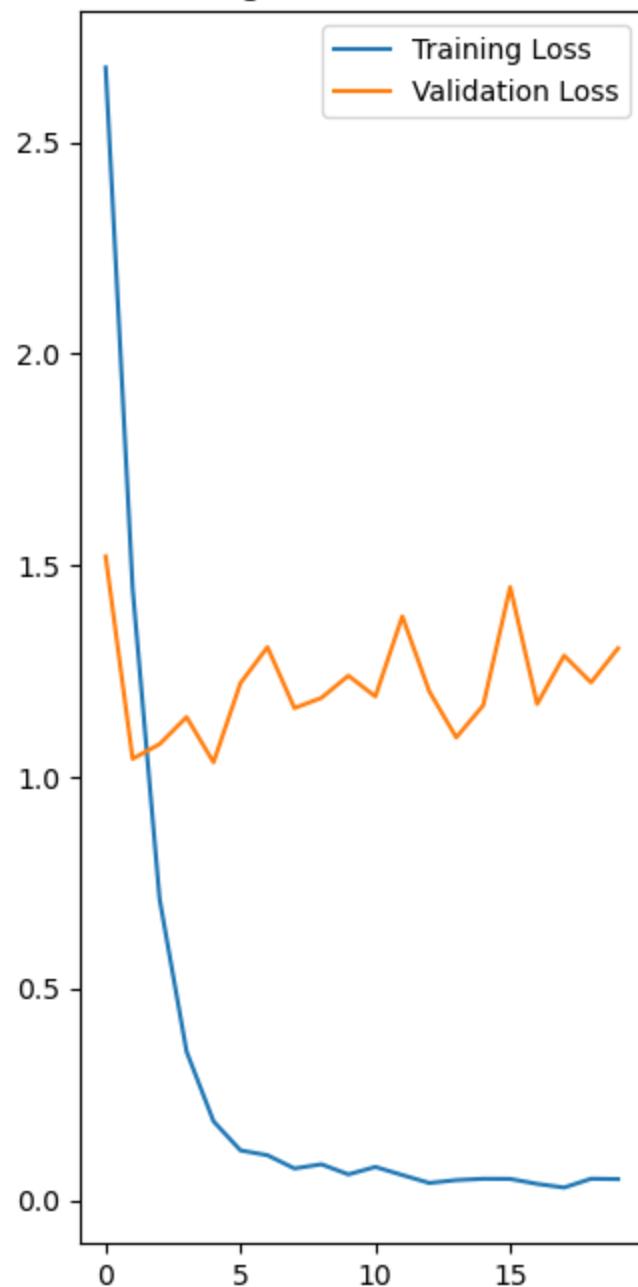
plt.figure(figsize=(8, 8))
plt.subplot(1, 2, 1)
plt.plot(epochs_range, acc, label='Training Accuracy')
plt.plot(epochs_range, val_acc, label='Validation Accuracy')
plt.legend(loc='lower right')
plt.title('Training and Validation Accuracy')

plt.subplot(1, 2, 2)
plt.plot(epochs_range, loss, label='Training Loss')
plt.plot(epochs_range, val_loss, label='Validation Loss')
plt.legend(loc='upper right')
plt.title('Training and Validation Loss')
plt.show()
```

Training and Validation Accuracy



Training and Validation Loss



```
In [19]: eval_result = model_bhp.evaluate(test_ds)
print("[test loss, test accuracy]:", eval_result)
```

```
239/239 [=====] - 4s 17ms/step - loss: 0.0125 - accuracy: 0.9980
[test loss, test accuracy]: [0.012543204240500927, 0.9980325102806091]
```

```
In [ ]:
```