ML_Final_Cruise_SKF_copy

December 16, 2025

1 CISC5800: Machine Learning Final Project

1.0.1 *Creating a Convolutional Neural Network using a Plant Leaf Diseases Training Dataset from Kaggle*

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1.1.1 Part 8: Creating a Stratified K-Fold CNN

Unfortunately, I forgot to save any intermediary metrics before beginning the model. And since the model took about 14 hours to run, I will not be running it again. Nonetheless, this model has the best and most consistent performance of any model I used. I was able to save the models and will include them in the GitHub.

[57]:
```
import os

#silencing warnings from tensorflow re: gpu use
os.environ["GRPC_VERBOSITY"] = "ERROR"
os.environ["GLOG_minloglevel"] = "2"
os.environ['TF_ENABLE_ONEDNN_OPTS'] = '0'

import tensorflow as tf
import numpy as np
import pandas as pd
from tensorflow import keras
from tensorflow.keras import layers, models
from tensorflow.keras.preprocessing.image import ImageDataGenerator
from sklearn.metrics import classification_report, confusion_matrix
from sklearn.model_selection import StratifiedKFold
from pathlib import Path
from PIL import Image
import glob
import time
import matplotlib.pyplot as plt
from sklearn.model_selection import StratifiedKFold

#verify local GPU being used by Tensorflow
tf.config.list_physical_devices('GPU')
```

[57]:
```
[PhysicalDevice(name='/physical_device:GPU:0', device_type='GPU')]
```

[4]:
```
#directory path of parent folder of all plant images
plant_dir = "/home/ryan/plant_data/plant-diseases-training-dataset"
parent = Path(plant_dir)

#list of names of each folder (class)
classes = [entry.name for entry in parent.iterdir() if entry.is_dir()]
class_onehot = [x for x in range(71)]

health_dir = []

#initialize empty class df
df_class = pd.DataFrame({'class': classes, 'y':class_onehot, 'plant': pd.NA,␣
 ↪'health': ['unhealthy'for x in range(len(classes))], 'count':np.nan})

#creates df of classes and thier counts
for cls in classes:
    #assigns class plant, health, and class count to each class
    p=Path(f'{plant_dir}/{cls}')
    count = sum(1 for entry in p.rglob('*') if entry.is_file())
    df_class.loc[df_class['class'] == cls, 'count'] = count

    #assigns plant type
    split = cls.split('___',1)
    df_class.loc[df_class['class'] == cls, 'plant'] = split[0]

    #create dir list to create classes of only <plant>_healthy and␣
 ↪<plant>_unhealthy
    if split[1] == 'healthy':
        health_dir.append(cls)
    elif (split[1] != 'healthy') & (f'{split[0]}___unhealthy' not in␣
 ↪health_dir):
        health_dir.append(f'{split[0]}___unhealthy')

    #assigns health of class
    if split[1] == 'healthy':
        df_class.loc[df_class['class'] == cls, 'health'] = 'healthy'

print(df_class.sort_values(by='count', ascending=False))
```

```
                        class   y       plant     health    count
45  Cassava___mosaic_disease  45     Cassava  unhealthy  13158.0
51  Orange___citrus_greening  51      Orange  unhealthy   5507.0
57        Tomato___leaf_curl  57      Tomato  unhealthy   5357.0
49         Soybean___healthy  49     Soybean    healthy   5090.0
63        Rose___slug_sawfly  63        Rose  unhealthy   4979.0
..                       ...  ..         ...        ...      ...
```

```
69        Apple___brown_spot  69       Apple  unhealthy    215.0
2       Watermelon___healthy   2  Watermelon    healthy    205.0
21  Coffee___red_spider_mite  21      Coffee  unhealthy    167.0
65  Watermelon___anthracnose  65  Watermelon  unhealthy    155.0
67         Potato___nematode  67      Potato  unhealthy     68.0

[71 rows x 5 columns]
```

[114]:
```
skf_dir = "/home/ryan/plants_skf"
plant_dir = "/home/ryan/plant_data/plant-diseases-training-dataset"
parent = Path(skf_dir)
parent_class = Path(plant_dir)

#list of names of each folder (class)
classes = [entry.name for entry in parent_class.iterdir() if entry.is_dir()]
files = [entry.name for entry in parent.iterdir() if entry.is_file()]
class_onehot = [x for x in range(71)]

df_onehot = pd.DataFrame({"class":classes, "one_hot":class_onehot})

# Initialize an empty DataFrame with columns
df_class = pd.DataFrame(columns=['file','class','img','onehot'])

for file in files:
    #assigns plant type
    split = file.split('-',1)
    cls = split[0]
    img = split[1]
    onehot = df_onehot.loc[df_onehot["class"] == cls, "one_hot"].values[0]
    df_class.loc[len(df_class)] = {'file':file,'class': cls, 'img': img,␣
 ↪'onehot':onehot}

print(df_class)
```

```
                                    file                    class  \
0             Tomato___leaf_curl-89828.jpg       Tomato___leaf_curl
1             Corn___common_rust-50205.jpg       Corn___common_rust
2               Grape___healthy-105584.jpg          Grape___healthy
3          Tomato___early_blight-80856.jpg    Tomato___early_blight
4           Sugercane___mosaic-106479.jpeg       Sugercane___mosaic
…                                      …                       …
116142        Grape___black_rot-110744.jpg        Grape___black_rot
116143                Rose___rust-7365.jpg              Rose___rust
116144     Potato___early_blight-67452.jpg    Potato___early_blight
116145              Rose___healthy-123.jpg           Rose___healthy
116146  Cassava___mosaic_disease-25259.jpg  Cassava___mosaic_disease
```

```
                img  onehot
0         89828.jpg      57
1         50205.jpg      39
2        105584.jpg      20
3         80856.jpg      32
4       106479.jpeg      60
…              …     …
116142   110744.jpg      56
116143     7365.jpg       4
116144    67452.jpg      17
116145      123.jpg      61
116146    25259.jpg      45

[116147 rows x 4 columns]
```

[115]:
```
idg = ImageDataGenerator(
    width_shift_range=0.1,
    height_shift_range=0.1,
    zoom_range=0.3,
    fill_mode='nearest',
    horizontal_flip=True)
```

[116]:
```
y  = np.array(df_class['class'])
nsamp = y.shape[0]
print(y)
print(nsamp)
```

```
['Tomato___leaf_curl' 'Corn___common_rust' 'Grape___healthy' …
 'Potato___early_blight' 'Rose___healthy' 'Cassava___mosaic_disease']
116147
```

[117]:
```
print(len(np.unique(y)))
```

```
71
```

[133]:
```
def custom_cnn(input_shape, nclasses):

    inputs = keras.Input(shape=input_shape)

    #Rescale pixels to [-1,1]
    x = layers.Rescaling(1./127.5, offset=-1.0)(inputs)

    #Stack 1 - convolution round 1, maxpooling
    x = layers.Conv2D(32, (3,3), padding="same", activation="relu")(x)
    x = layers.Conv2D(32, (3,3), padding="same", activation="relu")(x)
    x = layers.MaxPooling2D((2,2))(x)

    #Stack 2 - convolution round 2, maxpooling
    x = layers.Conv2D(64, (3,3), padding="same", activation="relu")(x)
```

```
    x = layers.Conv2D(64, (3,3), padding="same", activation="relu")(x)
    x = layers.MaxPooling2D((2,2))(x)

     #Stack 3 - Convolution round 3, maxpooling
    x = layers.Conv2D(128, (3,3), padding="same", activation="relu")(x)
    x = layers.Conv2D(128, (3,3), padding="same", activation="relu")(x)
    x = layers.Conv2D(128, (3,3), padding="same", activation="relu")(x)
    x = layers.MaxPooling2D((2,2))(x)

    #reduces dimensionality
    x = layers.GlobalAveragePooling2D()(x)

    #drop 50% neurons to prevent overfitting before sending to FC layer
    x = layers.Dropout(0.5)(x)
    x = layers.Dense(128, activation="relu")(x) #the only FC layer outside of␣
 ↪the output layer
    x = layers.Dropout(0.5)(x) #drop 50% neurons to prevent overfitting before␣
 ↪sending to output layer

    #output layer - softmax function
    outputs = layers.Dense(nclasses, activation="softmax")(x)

    model = keras.Model(inputs=inputs, outputs=outputs)

    return model
```

[135]:
```
y  = np.array(df_class['class'])
nsamp = y.shape[0]

skf_save="/home/ryan/skf_save"

y_mod = []
ypred_mod = []
val_loss = []
val_acc = []

input_shape = (256,256,3)

skf = StratifiedKFold(n_splits=5, shuffle=True)

for i, (tr_idx, ts_idx) in enumerate(skf.split(np.zeros(nsamp),y)):

    print(f"=========================FOLD {i}=========================")

    #load tr and ts indices
    tr_data = df_class.iloc[tr_idx]
    ts_data = df_class.iloc[ts_idx]
```

```
   #load training and testing images
   tr_dg = idg.flow_from_dataframe(tr_data, directory=skf_dir, x_col="file",␣
↪y_col="class",
                                   class_mode="categorical", shuffle=True,␣
↪batch_size=64, target_size=(256,256))

   ts_dg = idg.flow_from_dataframe(ts_data, directory=skf_dir, x_col="file",␣
↪y_col="class",
                                   class_mode="categorical",shuffle=False,␣
↪batch_size=64, target_size=(256,256))

   #create new instance of model
   model = cnn_model(input_shape, len(np.unique(y)))

   #compile model
   model.compile(
       optimizer=keras.optimizers.Adam(learning_rate=1e-3),
       loss="categorical_crossentropy",
       metrics=["accuracy"])

   #create callbacks
   chkpoints = [tf.keras.callbacks.ModelCheckpoint(f"{skf_save}/model_{i}.
↪keras", monitor='val_loss', verbose=1,
                                                   save_best_only=True,␣
↪mode='min')]

   #Early Stopping for efficiency
   earlystop = [keras.callbacks.EarlyStopping(
           monitor = "val_loss",
           patience = 3,
           restore_best_weights=True)]

   callbacks = chkpoints + earlystop

   history = model.fit(tr_dg, steps_per_epoch=len(tr_dg),␣
↪validation_data=ts_dg, validation_steps=len(ts_dg), epochs=20,␣
↪callbacks=callbacks)

   pred = model.evaluate(ts_dg)
   pred = dict(zip(model.metrics_names, pred))
   val_acc.append(pred['compile_metrics'])
   val_loss.append(pred['loss'])

   print(val_acc)
   print(val_loss)
```

```
    tf.keras.backend.clear_session()
```

```
=======================FOLD 0=======================
Found 92917 validated image filenames belonging to 71 classes.
Found 23230 validated image filenames belonging to 71 classes.
Epoch 1/20
1452/1452            0s 271ms/step -
accuracy: 0.2019 - loss: 3.2517
Epoch 1: val_loss improved from None to 1.92138, saving model to
/home/ryan/skf_save/model_0.keras
1452/1452            497s 339ms/step
- accuracy: 0.2783 - loss: 2.7928 - val_accuracy: 0.4521 - val_loss: 1.9214
Epoch 2/20
1452/1452            0s 265ms/step -
accuracy: 0.4120 - loss: 2.0638
Epoch 2: val_loss improved from 1.92138 to 1.44925, saving model to
/home/ryan/skf_save/model_0.keras
1452/1452            480s 330ms/step
- accuracy: 0.4396 - loss: 1.9359 - val_accuracy: 0.5550 - val_loss: 1.4492
Epoch 3/20
1452/1452            0s 260ms/step -
accuracy: 0.5126 - loss: 1.6165
Epoch 3: val_loss improved from 1.44925 to 1.34271, saving model to
/home/ryan/skf_save/model_0.keras
1452/1452            472s 325ms/step
- accuracy: 0.5320 - loss: 1.5479 - val_accuracy: 0.6119 - val_loss: 1.3427
Epoch 4/20
1452/1452            0s 268ms/step -
accuracy: 0.5766 - loss: 1.3823
Epoch 4: val_loss improved from 1.34271 to 0.85543, saving model to
/home/ryan/skf_save/model_0.keras
1452/1452            485s 334ms/step
- accuracy: 0.5994 - loss: 1.3008 - val_accuracy: 0.7310 - val_loss: 0.8554
Epoch 5/20
1452/1452            0s 260ms/step -
accuracy: 0.6444 - loss: 1.1499
Epoch 5: val_loss improved from 0.85543 to 0.71945, saving model to
/home/ryan/skf_save/model_0.keras
1452/1452            474s 326ms/step
- accuracy: 0.6551 - loss: 1.1163 - val_accuracy: 0.7728 - val_loss: 0.7194
Epoch 6/20
1452/1452            0s 262ms/step -
accuracy: 0.6805 - loss: 1.0246
Epoch 6: val_loss improved from 0.71945 to 0.66173, saving model to
/home/ryan/skf_save/model_0.keras
1452/1452            477s 328ms/step
- accuracy: 0.6868 - loss: 1.0065 - val_accuracy: 0.7847 - val_loss: 0.6617
Epoch 7/20
```

```
1452/1452            0s 263ms/step -
accuracy: 0.7024 - loss: 0.9466
Epoch 7: val_loss improved from 0.66173 to 0.60876, saving model to
/home/ryan/skf_save/model_0.keras
1452/1452            478s 329ms/step
- accuracy: 0.7099 - loss: 0.9263 - val_accuracy: 0.8098 - val_loss: 0.6088
Epoch 8/20
1452/1452            0s 263ms/step -
accuracy: 0.7243 - loss: 0.8770
Epoch 8: val_loss improved from 0.60876 to 0.57963, saving model to
/home/ryan/skf_save/model_0.keras
1452/1452            477s 329ms/step
- accuracy: 0.7276 - loss: 0.8681 - val_accuracy: 0.8100 - val_loss: 0.5796
Epoch 9/20
1452/1452            0s 256ms/step -
accuracy: 0.7424 - loss: 0.8188
Epoch 9: val_loss improved from 0.57963 to 0.53800, saving model to
/home/ryan/skf_save/model_0.keras
1452/1452            468s 322ms/step
- accuracy: 0.7456 - loss: 0.8082 - val_accuracy: 0.8242 - val_loss: 0.5380
Epoch 10/20
1452/1452            0s 265ms/step -
accuracy: 0.7567 - loss: 0.7726
Epoch 10: val_loss improved from 0.53800 to 0.49139, saving model to
/home/ryan/skf_save/model_0.keras
1452/1452            480s 331ms/step
- accuracy: 0.7602 - loss: 0.7632 - val_accuracy: 0.8391 - val_loss: 0.4914
Epoch 11/20
1452/1452            0s 261ms/step -
accuracy: 0.7679 - loss: 0.7336
Epoch 11: val_loss improved from 0.49139 to 0.46891, saving model to
/home/ryan/skf_save/model_0.keras
1452/1452            475s 327ms/step
- accuracy: 0.7664 - loss: 0.7373 - val_accuracy: 0.8461 - val_loss: 0.4689
Epoch 12/20
1452/1452            0s 267ms/step -
accuracy: 0.7821 - loss: 0.6934
Epoch 12: val_loss improved from 0.46891 to 0.43259, saving model to
/home/ryan/skf_save/model_0.keras
1452/1452            482s 332ms/step
- accuracy: 0.7818 - loss: 0.6899 - val_accuracy: 0.8560 - val_loss: 0.4326
Epoch 13/20
1452/1452            0s 263ms/step -
accuracy: 0.7895 - loss: 0.6702
Epoch 13: val_loss improved from 0.43259 to 0.43206, saving model to
/home/ryan/skf_save/model_0.keras
1452/1452            478s 329ms/step
- accuracy: 0.7904 - loss: 0.6646 - val_accuracy: 0.8591 - val_loss: 0.4321
```

```
Epoch 14/20
1452/1452            0s 264ms/step -
accuracy: 0.7927 - loss: 0.6462
Epoch 14: val_loss improved from 0.43206 to 0.39782, saving model to
/home/ryan/skf_save/model_0.keras
1452/1452            479s 330ms/step
- accuracy: 0.7941 - loss: 0.6483 - val_accuracy: 0.8681 - val_loss: 0.3978
Epoch 15/20
1452/1452            0s 264ms/step -
accuracy: 0.8033 - loss: 0.6197
Epoch 15: val_loss improved from 0.39782 to 0.39228, saving model to
/home/ryan/skf_save/model_0.keras
1452/1452            479s 329ms/step
- accuracy: 0.8037 - loss: 0.6189 - val_accuracy: 0.8708 - val_loss: 0.3923
Epoch 16/20
1452/1452            0s 264ms/step -
accuracy: 0.8052 - loss: 0.6074
Epoch 16: val_loss did not improve from 0.39228
1452/1452            478s 329ms/step
- accuracy: 0.8082 - loss: 0.6013 - val_accuracy: 0.8700 - val_loss: 0.3971
Epoch 17/20
1452/1452            0s 264ms/step -
accuracy: 0.8121 - loss: 0.5841
Epoch 17: val_loss improved from 0.39228 to 0.35462, saving model to
/home/ryan/skf_save/model_0.keras
1452/1452            480s 330ms/step
- accuracy: 0.8136 - loss: 0.5849 - val_accuracy: 0.8850 - val_loss: 0.3546
Epoch 18/20
1452/1452            0s 263ms/step -
accuracy: 0.8197 - loss: 0.5616
Epoch 18: val_loss did not improve from 0.35462
1452/1452            478s 329ms/step
- accuracy: 0.8183 - loss: 0.5668 - val_accuracy: 0.8814 - val_loss: 0.3673
Epoch 19/20
1452/1452            0s 260ms/step -
accuracy: 0.8264 - loss: 0.5422
Epoch 19: val_loss did not improve from 0.35462
1452/1452            472s 325ms/step
- accuracy: 0.8241 - loss: 0.5474 - val_accuracy: 0.8818 - val_loss: 0.3589
Epoch 20/20
1452/1452            0s 260ms/step -
accuracy: 0.8251 - loss: 0.5486
Epoch 20: val_loss improved from 0.35462 to 0.35070, saving model to
/home/ryan/skf_save/model_0.keras
1452/1452            474s 326ms/step
- accuracy: 0.8252 - loss: 0.5489 - val_accuracy: 0.8836 - val_loss: 0.3507
363/363             95s 260ms/step -
accuracy: 0.8826 - loss: 0.3490
```

```
[0.8826087117195129]
[0.34899380803108215]
=======================FOLD 1=======================
Found 92917 validated image filenames belonging to 71 classes.
Found 23230 validated image filenames belonging to 71 classes.
Epoch 1/20
1452/1452            0s 257ms/step -
accuracy: 0.1897 - loss: 3.3270
Epoch 1: val_loss improved from None to 2.07044, saving model to
/home/ryan/skf_save/model_1.keras
1452/1452            477s 325ms/step
- accuracy: 0.2594 - loss: 2.8878 - val_accuracy: 0.4225 - val_loss: 2.0704
Epoch 2/20
1452/1452            0s 265ms/step -
accuracy: 0.4108 - loss: 2.0994
Epoch 2: val_loss improved from 2.07044 to 1.50069, saving model to
/home/ryan/skf_save/model_1.keras
1452/1452            481s 331ms/step
- accuracy: 0.4382 - loss: 1.9764 - val_accuracy: 0.5680 - val_loss: 1.5007
Epoch 3/20
1452/1452            0s 265ms/step -
accuracy: 0.5143 - loss: 1.6700
Epoch 3: val_loss improved from 1.50069 to 1.11962, saving model to
/home/ryan/skf_save/model_1.keras
1452/1452            481s 331ms/step
- accuracy: 0.5326 - loss: 1.5897 - val_accuracy: 0.6562 - val_loss: 1.1196
Epoch 4/20
1452/1452            0s 263ms/step -
accuracy: 0.5852 - loss: 1.3835
Epoch 4: val_loss improved from 1.11962 to 0.93049, saving model to
/home/ryan/skf_save/model_1.keras
1452/1452            477s 329ms/step
- accuracy: 0.5970 - loss: 1.3365 - val_accuracy: 0.7101 - val_loss: 0.9305
Epoch 5/20
1452/1452            0s 263ms/step -
accuracy: 0.6360 - loss: 1.1949
Epoch 5: val_loss improved from 0.93049 to 0.85172, saving model to
/home/ryan/skf_save/model_1.keras
1452/1452            478s 329ms/step
- accuracy: 0.6454 - loss: 1.1639 - val_accuracy: 0.7423 - val_loss: 0.8517
Epoch 6/20
1452/1452            0s 265ms/step -
accuracy: 0.6736 - loss: 1.0632
Epoch 6: val_loss improved from 0.85172 to 0.70528, saving model to
/home/ryan/skf_save/model_1.keras
1452/1452            481s 331ms/step
- accuracy: 0.6803 - loss: 1.0379 - val_accuracy: 0.7780 - val_loss: 0.7053
Epoch 7/20
```

```
1452/1452            0s 260ms/step -
accuracy: 0.7035 - loss: 0.9592
Epoch 7: val_loss improved from 0.70528 to 0.63738, saving model to
/home/ryan/skf_save/model_1.keras
1452/1452            474s 326ms/step
- accuracy: 0.7066 - loss: 0.9480 - val_accuracy: 0.7951 - val_loss: 0.6374
Epoch 8/20
1447/1452            1s 266ms/step -
accuracy: 0.7247 - loss: 0.8833
Epoch 8: val_loss improved from 0.63738 to 0.59569, saving model to
/home/ryan/skf_save/model_1.keras
1452/1452            479s 330ms/step
- accuracy: 0.7296 - loss: 0.8676 - val_accuracy: 0.8113 - val_loss: 0.5957
Epoch 9/20
1452/1452            0s 265ms/step -
accuracy: 0.7433 - loss: 0.8141
Epoch 9: val_loss improved from 0.59569 to 0.51739, saving model to
/home/ryan/skf_save/model_1.keras
1452/1452            481s 331ms/step
- accuracy: 0.7460 - loss: 0.8080 - val_accuracy: 0.8317 - val_loss: 0.5174
Epoch 10/20
1452/1452            0s 265ms/step -
accuracy: 0.7564 - loss: 0.7809
Epoch 10: val_loss did not improve from 0.51739
1452/1452            483s 332ms/step
- accuracy: 0.7575 - loss: 0.7722 - val_accuracy: 0.8205 - val_loss: 0.5416
Epoch 11/20
1452/1452            0s 263ms/step -
accuracy: 0.7666 - loss: 0.7381
Epoch 11: val_loss improved from 0.51739 to 0.49263, saving model to
/home/ryan/skf_save/model_1.keras
1452/1452            478s 329ms/step
- accuracy: 0.7686 - loss: 0.7310 - val_accuracy: 0.8373 - val_loss: 0.4926
Epoch 12/20
1452/1452            0s 260ms/step -
accuracy: 0.7756 - loss: 0.7046
Epoch 12: val_loss improved from 0.49263 to 0.46742, saving model to
/home/ryan/skf_save/model_1.keras
1452/1452            474s 326ms/step
- accuracy: 0.7764 - loss: 0.7006 - val_accuracy: 0.8475 - val_loss: 0.4674
Epoch 13/20
1452/1452            0s 255ms/step -
accuracy: 0.7837 - loss: 0.6763
Epoch 13: val_loss improved from 0.46742 to 0.44605, saving model to
/home/ryan/skf_save/model_1.keras
1452/1452            467s 321ms/step
- accuracy: 0.7860 - loss: 0.6701 - val_accuracy: 0.8556 - val_loss: 0.4461
Epoch 14/20
```

```
1452/1452            0s 264ms/step -
accuracy: 0.7894 - loss: 0.6517
Epoch 14: val_loss improved from 0.44605 to 0.42766, saving model to
/home/ryan/skf_save/model_1.keras
1452/1452            478s 329ms/step
- accuracy: 0.7931 - loss: 0.6436 - val_accuracy: 0.8565 - val_loss: 0.4277
Epoch 15/20
1452/1452            0s 261ms/step -
accuracy: 0.7978 - loss: 0.6305
Epoch 15: val_loss improved from 0.42766 to 0.42689, saving model to
/home/ryan/skf_save/model_1.keras
1452/1452            473s 326ms/step
- accuracy: 0.7997 - loss: 0.6273 - val_accuracy: 0.8600 - val_loss: 0.4269
Epoch 16/20
1452/1452            0s 295ms/step -
accuracy: 0.8038 - loss: 0.6150
Epoch 16: val_loss did not improve from 0.42689
1452/1452            524s 360ms/step
- accuracy: 0.8047 - loss: 0.6087 - val_accuracy: 0.8589 - val_loss: 0.4298
Epoch 17/20
1452/1452            0s 262ms/step -
accuracy: 0.8074 - loss: 0.5939
Epoch 17: val_loss improved from 0.42689 to 0.39494, saving model to
/home/ryan/skf_save/model_1.keras
1452/1452            474s 327ms/step
- accuracy: 0.8090 - loss: 0.5946 - val_accuracy: 0.8704 - val_loss: 0.3949
Epoch 18/20
1452/1452            0s 260ms/step -
accuracy: 0.8169 - loss: 0.5766
Epoch 18: val_loss improved from 0.39494 to 0.39227, saving model to
/home/ryan/skf_save/model_1.keras
1452/1452            473s 326ms/step
- accuracy: 0.8160 - loss: 0.5779 - val_accuracy: 0.8689 - val_loss: 0.3923
Epoch 19/20
1452/1452            0s 254ms/step -
accuracy: 0.8213 - loss: 0.5534
Epoch 19: val_loss improved from 0.39227 to 0.37107, saving model to
/home/ryan/skf_save/model_1.keras
1452/1452            464s 319ms/step
- accuracy: 0.8217 - loss: 0.5537 - val_accuracy: 0.8773 - val_loss: 0.3711
Epoch 20/20
1452/1452            0s 270ms/step -
accuracy: 0.8245 - loss: 0.5450
Epoch 20: val_loss improved from 0.37107 to 0.35617, saving model to
/home/ryan/skf_save/model_1.keras
1452/1452            487s 336ms/step
- accuracy: 0.8244 - loss: 0.5500 - val_accuracy: 0.8828 - val_loss: 0.3562
363/363             93s 257ms/step -
```

```
accuracy: 0.8818 - loss: 0.3553
[0.8826087117195129, 0.8818338513374329]
[0.34899380803108215, 0.3553321957588196]
=======================FOLD 2=======================
Found 92918 validated image filenames belonging to 71 classes.
Found 23229 validated image filenames belonging to 71 classes.
Epoch 1/20
1452/1452            0s 254ms/step -
accuracy: 0.2010 - loss: 3.2905
Epoch 1: val_loss improved from None to 1.96930, saving model to
/home/ryan/skf_save/model_2.keras
1452/1452            467s 318ms/step
- accuracy: 0.2734 - loss: 2.8291 - val_accuracy: 0.4554 - val_loss: 1.9693
Epoch 2/20
1452/1452            0s 264ms/step -
accuracy: 0.4216 - loss: 2.0454
Epoch 2: val_loss improved from 1.96930 to 1.42771, saving model to
/home/ryan/skf_save/model_2.keras
1452/1452            479s 329ms/step
- accuracy: 0.4489 - loss: 1.9227 - val_accuracy: 0.5690 - val_loss: 1.4277
Epoch 3/20
1452/1452            0s 263ms/step -
accuracy: 0.5238 - loss: 1.6378
Epoch 3: val_loss improved from 1.42771 to 1.16152, saving model to
/home/ryan/skf_save/model_2.keras
1452/1452            476s 327ms/step
- accuracy: 0.5423 - loss: 1.5665 - val_accuracy: 0.6561 - val_loss: 1.1615
Epoch 4/20
1452/1452            0s 260ms/step -
accuracy: 0.5840 - loss: 1.3921
Epoch 4: val_loss improved from 1.16152 to 1.00777, saving model to
/home/ryan/skf_save/model_2.keras
1452/1452            471s 324ms/step
- accuracy: 0.5925 - loss: 1.3570 - val_accuracy: 0.6919 - val_loss: 1.0078
Epoch 5/20
1452/1452            0s 261ms/step -
accuracy: 0.6254 - loss: 1.2342
Epoch 5: val_loss improved from 1.00777 to 0.82206, saving model to
/home/ryan/skf_save/model_2.keras
1452/1452            473s 326ms/step
- accuracy: 0.6346 - loss: 1.1985 - val_accuracy: 0.7439 - val_loss: 0.8221
Epoch 6/20
1452/1452            0s 254ms/step -
accuracy: 0.6584 - loss: 1.1152
Epoch 6: val_loss improved from 0.82206 to 0.81754, saving model to
/home/ryan/skf_save/model_2.keras
1452/1452            463s 319ms/step
- accuracy: 0.6656 - loss: 1.0876 - val_accuracy: 0.7516 - val_loss: 0.8175
```

```
Epoch 7/20
1452/1452            0s 263ms/step -
accuracy: 0.6860 - loss: 1.0186
Epoch 7: val_loss improved from 0.81754 to 0.69800, saving model to
/home/ryan/skf_save/model_2.keras
1452/1452            476s 328ms/step
- accuracy: 0.6919 - loss: 0.9962 - val_accuracy: 0.7867 - val_loss: 0.6980
Epoch 8/20
1452/1452            0s 261ms/step -
accuracy: 0.7088 - loss: 0.9312
Epoch 8: val_loss improved from 0.69800 to 0.61836, saving model to
/home/ryan/skf_save/model_2.keras
1452/1452            474s 326ms/step
- accuracy: 0.7141 - loss: 0.9131 - val_accuracy: 0.8005 - val_loss: 0.6184
Epoch 9/20
1452/1452            0s 262ms/step -
accuracy: 0.7252 - loss: 0.8716
Epoch 9: val_loss improved from 0.61836 to 0.55283, saving model to
/home/ryan/skf_save/model_2.keras
1452/1452            504s 327ms/step
- accuracy: 0.7282 - loss: 0.8622 - val_accuracy: 0.8258 - val_loss: 0.5528
Epoch 10/20
1452/1452            0s 261ms/step -
accuracy: 0.7384 - loss: 0.8285
Epoch 10: val_loss improved from 0.55283 to 0.52274, saving model to
/home/ryan/skf_save/model_2.keras
1452/1452            474s 326ms/step
- accuracy: 0.7435 - loss: 0.8164 - val_accuracy: 0.8321 - val_loss: 0.5227
Epoch 11/20
1452/1452            0s 260ms/step -
accuracy: 0.7526 - loss: 0.7872
Epoch 11: val_loss did not improve from 0.52274
1452/1452            472s 325ms/step
- accuracy: 0.7563 - loss: 0.7715 - val_accuracy: 0.8216 - val_loss: 0.5624
Epoch 12/20
1452/1452            0s 257ms/step -
accuracy: 0.7667 - loss: 0.7331
Epoch 12: val_loss improved from 0.52274 to 0.50678, saving model to
/home/ryan/skf_save/model_2.keras
1452/1452            468s 322ms/step
- accuracy: 0.7692 - loss: 0.7258 - val_accuracy: 0.8363 - val_loss: 0.5068
Epoch 13/20
1452/1452            0s 262ms/step -
accuracy: 0.7722 - loss: 0.7169
Epoch 13: val_loss improved from 0.50678 to 0.46154, saving model to
/home/ryan/skf_save/model_2.keras
1452/1452            475s 327ms/step
- accuracy: 0.7758 - loss: 0.7061 - val_accuracy: 0.8511 - val_loss: 0.4615
```

```
Epoch 14/20
1452/1452            0s 258ms/step -
accuracy: 0.7861 - loss: 0.6810
Epoch 14: val_loss improved from 0.46154 to 0.43118, saving model to
/home/ryan/skf_save/model_2.keras
1452/1452            470s 324ms/step
- accuracy: 0.7846 - loss: 0.6792 - val_accuracy: 0.8620 - val_loss: 0.4312
Epoch 15/20
1452/1452            0s 262ms/step -
accuracy: 0.7897 - loss: 0.6541
Epoch 15: val_loss improved from 0.43118 to 0.40243, saving model to
/home/ryan/skf_save/model_2.keras
1452/1452            476s 327ms/step
- accuracy: 0.7916 - loss: 0.6526 - val_accuracy: 0.8708 - val_loss: 0.4024
Epoch 16/20
1452/1452            0s 261ms/step -
accuracy: 0.7996 - loss: 0.6350
Epoch 16: val_loss did not improve from 0.40243
1452/1452            473s 326ms/step
- accuracy: 0.7973 - loss: 0.6393 - val_accuracy: 0.8667 - val_loss: 0.4033
Epoch 17/20
1452/1452            0s 252ms/step -
accuracy: 0.7994 - loss: 0.6218
Epoch 17: val_loss improved from 0.40243 to 0.39169, saving model to
/home/ryan/skf_save/model_2.keras
1452/1452            460s 317ms/step
- accuracy: 0.8007 - loss: 0.6178 - val_accuracy: 0.8736 - val_loss: 0.3917
Epoch 18/20
1452/1452            0s 252ms/step -
accuracy: 0.8078 - loss: 0.5899
Epoch 18: val_loss improved from 0.39169 to 0.37272, saving model to
/home/ryan/skf_save/model_2.keras
1452/1452            461s 317ms/step
- accuracy: 0.8086 - loss: 0.5946 - val_accuracy: 0.8772 - val_loss: 0.3727
Epoch 19/20
1452/1452            0s 259ms/step -
accuracy: 0.8134 - loss: 0.5785
Epoch 19: val_loss did not improve from 0.37272
1452/1452            469s 323ms/step
- accuracy: 0.8128 - loss: 0.5829 - val_accuracy: 0.8715 - val_loss: 0.3944
Epoch 20/20
1452/1452            0s 261ms/step -
accuracy: 0.8157 - loss: 0.5771
Epoch 20: val_loss did not improve from 0.37272
1452/1452            473s 325ms/step
- accuracy: 0.8175 - loss: 0.5703 - val_accuracy: 0.8797 - val_loss: 0.3738
363/363             94s 258ms/step -
accuracy: 0.8760 - loss: 0.3733
```

```
[0.8826087117195129, 0.8818338513374329, 0.8760170340538025]
[0.34899380803108215, 0.3553321957588196, 0.37334582209587097]
=======================FOLD 3=======================
Found 92918 validated image filenames belonging to 71 classes.
Found 23229 validated image filenames belonging to 71 classes.
Epoch 1/20
1451/1452            0s 249ms/step -
accuracy: 0.1982 - loss: 3.2699
Epoch 1: val_loss improved from None to 1.95430, saving model to
/home/ryan/skf_save/model_3.keras
1452/1452            461s 315ms/step
- accuracy: 0.2715 - loss: 2.8105 - val_accuracy: 0.4473 - val_loss: 1.9543
Epoch 2/20
1452/1452            0s 260ms/step -
accuracy: 0.4269 - loss: 2.0260
Epoch 2: val_loss improved from 1.95430 to 1.32376, saving model to
/home/ryan/skf_save/model_3.keras
1452/1452            473s 326ms/step
- accuracy: 0.4618 - loss: 1.8802 - val_accuracy: 0.5965 - val_loss: 1.3238
Epoch 3/20
1452/1452            0s 260ms/step -
accuracy: 0.5424 - loss: 1.5582
Epoch 3: val_loss improved from 1.32376 to 1.05697, saving model to
/home/ryan/skf_save/model_3.keras
1452/1452            471s 324ms/step
- accuracy: 0.5666 - loss: 1.4676 - val_accuracy: 0.6794 - val_loss: 1.0570
Epoch 4/20
1452/1452            0s 256ms/step -
accuracy: 0.6130 - loss: 1.2887
Epoch 4: val_loss improved from 1.05697 to 0.89923, saving model to
/home/ryan/skf_save/model_3.keras
1452/1452            466s 321ms/step
- accuracy: 0.6249 - loss: 1.2462 - val_accuracy: 0.7144 - val_loss: 0.8992
Epoch 5/20
1452/1452            0s 261ms/step -
accuracy: 0.6558 - loss: 1.1387
Epoch 5: val_loss improved from 0.89923 to 0.73313, saving model to
/home/ryan/skf_save/model_3.keras
1452/1452            474s 326ms/step
- accuracy: 0.6661 - loss: 1.1034 - val_accuracy: 0.7666 - val_loss: 0.7331
Epoch 6/20
1452/1452            0s 262ms/step -
accuracy: 0.6871 - loss: 1.0254
Epoch 6: val_loss improved from 0.73313 to 0.70829, saving model to
/home/ryan/skf_save/model_3.keras
1452/1452            474s 327ms/step
- accuracy: 0.6942 - loss: 1.0021 - val_accuracy: 0.7753 - val_loss: 0.7083
Epoch 7/20
```

```
1452/1452            0s 261ms/step -
accuracy: 0.7123 - loss: 0.9358
Epoch 7: val_loss improved from 0.70829 to 0.60918, saving model to
/home/ryan/skf_save/model_3.keras
1452/1452            473s 325ms/step
- accuracy: 0.7151 - loss: 0.9218 - val_accuracy: 0.8037 - val_loss: 0.6092
Epoch 8/20
1452/1452            0s 262ms/step -
accuracy: 0.7311 - loss: 0.8638
Epoch 8: val_loss improved from 0.60918 to 0.57621, saving model to
/home/ryan/skf_save/model_3.keras
1452/1452            475s 327ms/step
- accuracy: 0.7337 - loss: 0.8530 - val_accuracy: 0.8142 - val_loss: 0.5762
Epoch 9/20
1452/1452            0s 260ms/step -
accuracy: 0.7477 - loss: 0.8124
Epoch 9: val_loss improved from 0.57621 to 0.54339, saving model to
/home/ryan/skf_save/model_3.keras
1452/1452            472s 325ms/step
- accuracy: 0.7517 - loss: 0.8007 - val_accuracy: 0.8211 - val_loss: 0.5434
Epoch 10/20
1452/1452            0s 260ms/step -
accuracy: 0.7605 - loss: 0.7689
Epoch 10: val_loss improved from 0.54339 to 0.47699, saving model to
/home/ryan/skf_save/model_3.keras
1452/1452            473s 325ms/step
- accuracy: 0.7631 - loss: 0.7568 - val_accuracy: 0.8430 - val_loss: 0.4770
Epoch 11/20
1452/1452            0s 260ms/step -
accuracy: 0.7692 - loss: 0.7263
Epoch 11: val_loss did not improve from 0.47699
1452/1452            469s 323ms/step
- accuracy: 0.7726 - loss: 0.7221 - val_accuracy: 0.8411 - val_loss: 0.4936
Epoch 12/20
1452/1452            0s 260ms/step -
accuracy: 0.7806 - loss: 0.6899
Epoch 12: val_loss improved from 0.47699 to 0.44052, saving model to
/home/ryan/skf_save/model_3.keras
1452/1452            471s 324ms/step
- accuracy: 0.7825 - loss: 0.6856 - val_accuracy: 0.8557 - val_loss: 0.4405
Epoch 13/20
1452/1452            0s 260ms/step -
accuracy: 0.7862 - loss: 0.6716
Epoch 13: val_loss did not improve from 0.44052
1452/1452            472s 325ms/step
- accuracy: 0.7894 - loss: 0.6628 - val_accuracy: 0.8465 - val_loss: 0.4610
Epoch 14/20
1452/1452            0s 263ms/step -
```

```
accuracy: 0.7974 - loss: 0.6345
Epoch 14: val_loss improved from 0.44052 to 0.43402, saving model to
/home/ryan/skf_save/model_3.keras
1452/1452            475s 327ms/step
- accuracy: 0.7973 - loss: 0.6368 - val_accuracy: 0.8580 - val_loss: 0.4340
Epoch 15/20
1452/1452            0s 262ms/step -
accuracy: 0.8031 - loss: 0.6139
Epoch 15: val_loss improved from 0.43402 to 0.41356, saving model to
/home/ryan/skf_save/model_3.keras
1452/1452            474s 327ms/step
- accuracy: 0.8029 - loss: 0.6184 - val_accuracy: 0.8625 - val_loss: 0.4136
Epoch 16/20
1452/1452            0s 260ms/step -
accuracy: 0.8117 - loss: 0.5908
Epoch 16: val_loss improved from 0.41356 to 0.39300, saving model to
/home/ryan/skf_save/model_3.keras
1452/1452            471s 325ms/step
- accuracy: 0.8095 - loss: 0.5978 - val_accuracy: 0.8705 - val_loss: 0.3930
Epoch 17/20
1452/1452            0s 261ms/step -
accuracy: 0.8121 - loss: 0.5928
Epoch 17: val_loss improved from 0.39300 to 0.38017, saving model to
/home/ryan/skf_save/model_3.keras
1452/1452            472s 325ms/step
- accuracy: 0.8144 - loss: 0.5867 - val_accuracy: 0.8721 - val_loss: 0.3802
Epoch 18/20
1452/1452            0s 263ms/step -
accuracy: 0.8167 - loss: 0.5757
Epoch 18: val_loss improved from 0.38017 to 0.37913, saving model to
/home/ryan/skf_save/model_3.keras
1452/1452            476s 327ms/step
- accuracy: 0.8171 - loss: 0.5729 - val_accuracy: 0.8721 - val_loss: 0.3791
Epoch 19/20
1452/1452            0s 262ms/step -
accuracy: 0.8217 - loss: 0.5592
Epoch 19: val_loss did not improve from 0.37913
1452/1452            474s 327ms/step
- accuracy: 0.8218 - loss: 0.5564 - val_accuracy: 0.8711 - val_loss: 0.3937
Epoch 20/20
1452/1452            0s 262ms/step -
accuracy: 0.8244 - loss: 0.5450
Epoch 20: val_loss improved from 0.37913 to 0.37370, saving model to
/home/ryan/skf_save/model_3.keras
1452/1452            475s 327ms/step
- accuracy: 0.8255 - loss: 0.5426 - val_accuracy: 0.8803 - val_loss: 0.3737
363/363             94s 259ms/step -
accuracy: 0.8801 - loss: 0.3737
```

```
[0.8826087117195129, 0.8818338513374329, 0.8760170340538025, 0.8801498413085938]
[0.34899380803108215, 0.3553321957588196, 0.37334582209587097,
0.3736894130706787]
=======================FOLD 4=======================
Found 92918 validated image filenames belonging to 71 classes.
Found 23229 validated image filenames belonging to 71 classes.
Epoch 1/20
1452/1452            0s 258ms/step -
accuracy: 0.1823 - loss: 3.3442
Epoch 1: val_loss improved from None to 2.03295, saving model to
/home/ryan/skf_save/model_4.keras
1452/1452            474s 324ms/step
- accuracy: 0.2534 - loss: 2.9268 - val_accuracy: 0.4378 - val_loss: 2.0329
Epoch 2/20
1452/1452            0s 261ms/step -
accuracy: 0.4058 - loss: 2.1220
Epoch 2: val_loss improved from 2.03295 to 1.43353, saving model to
/home/ryan/skf_save/model_4.keras
1452/1452            473s 326ms/step
- accuracy: 0.4372 - loss: 1.9727 - val_accuracy: 0.5806 - val_loss: 1.4335
Epoch 3/20
1452/1452            0s 256ms/step -
accuracy: 0.5260 - loss: 1.6098
Epoch 3: val_loss improved from 1.43353 to 1.01754, saving model to
/home/ryan/skf_save/model_4.keras
1452/1452            467s 321ms/step
- accuracy: 0.5473 - loss: 1.5317 - val_accuracy: 0.6917 - val_loss: 1.0175
Epoch 4/20
1452/1452            0s 263ms/step -
accuracy: 0.6078 - loss: 1.3072
Epoch 4: val_loss improved from 1.01754 to 0.91164, saving model to
/home/ryan/skf_save/model_4.keras
1452/1452            475s 327ms/step
- accuracy: 0.6164 - loss: 1.2721 - val_accuracy: 0.7207 - val_loss: 0.9116
Epoch 5/20
1452/1452            0s 257ms/step -
accuracy: 0.6466 - loss: 1.1591
Epoch 5: val_loss improved from 0.91164 to 0.78473, saving model to
/home/ryan/skf_save/model_4.keras
1452/1452            467s 322ms/step
- accuracy: 0.6532 - loss: 1.1341 - val_accuracy: 0.7534 - val_loss: 0.7847
Epoch 6/20
1452/1452            0s 259ms/step -
accuracy: 0.6763 - loss: 1.0512
Epoch 6: val_loss improved from 0.78473 to 0.68475, saving model to
/home/ryan/skf_save/model_4.keras
1452/1452            471s 325ms/step
- accuracy: 0.6854 - loss: 1.0268 - val_accuracy: 0.7908 - val_loss: 0.6848
```

```
Epoch 7/20
1452/1452            0s 263ms/step -
accuracy: 0.7106 - loss: 0.9456
Epoch 7: val_loss improved from 0.68475 to 0.62902, saving model to
/home/ryan/skf_save/model_4.keras
1452/1452            474s 326ms/step
- accuracy: 0.7153 - loss: 0.9290 - val_accuracy: 0.8076 - val_loss: 0.6290
Epoch 8/20
1452/1452            0s 265ms/step -
accuracy: 0.7287 - loss: 0.8777
Epoch 8: val_loss improved from 0.62902 to 0.54317, saving model to
/home/ryan/skf_save/model_4.keras
1452/1452            480s 331ms/step
- accuracy: 0.7331 - loss: 0.8615 - val_accuracy: 0.8329 - val_loss: 0.5432
Epoch 9/20
1452/1452            0s 261ms/step -
accuracy: 0.7481 - loss: 0.8159
Epoch 9: val_loss did not improve from 0.54317
1452/1452            474s 326ms/step
- accuracy: 0.7484 - loss: 0.8122 - val_accuracy: 0.8313 - val_loss: 0.5479
Epoch 10/20
1452/1452            0s 261ms/step -
accuracy: 0.7592 - loss: 0.7707
Epoch 10: val_loss improved from 0.54317 to 0.49267, saving model to
/home/ryan/skf_save/model_4.keras
1452/1452            470s 324ms/step
- accuracy: 0.7610 - loss: 0.7675 - val_accuracy: 0.8420 - val_loss: 0.4927
Epoch 11/20
1452/1452            0s 264ms/step -
accuracy: 0.7729 - loss: 0.7271
Epoch 11: val_loss did not improve from 0.49267
1452/1452            476s 328ms/step
- accuracy: 0.7734 - loss: 0.7202 - val_accuracy: 0.8437 - val_loss: 0.5088
Epoch 12/20
1452/1452            0s 256ms/step -
accuracy: 0.7797 - loss: 0.6945
Epoch 12: val_loss improved from 0.49267 to 0.43452, saving model to
/home/ryan/skf_save/model_4.keras
1452/1452            467s 321ms/step
- accuracy: 0.7826 - loss: 0.6877 - val_accuracy: 0.8590 - val_loss: 0.4345
Epoch 13/20
1452/1452            0s 261ms/step -
accuracy: 0.7915 - loss: 0.6611
Epoch 13: val_loss did not improve from 0.43452
1452/1452            471s 324ms/step
- accuracy: 0.7911 - loss: 0.6650 - val_accuracy: 0.8566 - val_loss: 0.4405
Epoch 14/20
1452/1452            0s 264ms/step -
```

```
accuracy: 0.7945 - loss: 0.6495
Epoch 14: val_loss improved from 0.43452 to 0.40981, saving model to
/home/ryan/skf_save/model_4.keras
1452/1452            479s 330ms/step
- accuracy: 0.7969 - loss: 0.6421 - val_accuracy: 0.8664 - val_loss: 0.4098
Epoch 15/20
1452/1452            0s 262ms/step -
accuracy: 0.7999 - loss: 0.6294
Epoch 15: val_loss did not improve from 0.40981
1452/1452            476s 327ms/step
- accuracy: 0.8029 - loss: 0.6173 - val_accuracy: 0.8614 - val_loss: 0.4381
Epoch 16/20
1452/1452            0s 261ms/step -
accuracy: 0.8098 - loss: 0.6026
Epoch 16: val_loss improved from 0.40981 to 0.39443, saving model to
/home/ryan/skf_save/model_4.keras
1452/1452            471s 324ms/step
- accuracy: 0.8088 - loss: 0.6045 - val_accuracy: 0.8683 - val_loss: 0.3944
Epoch 17/20
1452/1452            0s 262ms/step -
accuracy: 0.8102 - loss: 0.5910
Epoch 17: val_loss did not improve from 0.39443
1452/1452            473s 326ms/step
- accuracy: 0.8127 - loss: 0.5867 - val_accuracy: 0.8635 - val_loss: 0.4000
Epoch 18/20
1452/1452            0s 258ms/step -
accuracy: 0.8146 - loss: 0.5713
Epoch 18: val_loss improved from 0.39443 to 0.37353, saving model to
/home/ryan/skf_save/model_4.keras
1452/1452            469s 323ms/step
- accuracy: 0.8179 - loss: 0.5680 - val_accuracy: 0.8717 - val_loss: 0.3735
Epoch 19/20
1452/1452            0s 259ms/step -
accuracy: 0.8244 - loss: 0.5542
Epoch 19: val_loss improved from 0.37353 to 0.37107, saving model to
/home/ryan/skf_save/model_4.keras
1452/1452            468s 322ms/step
- accuracy: 0.8226 - loss: 0.5578 - val_accuracy: 0.8769 - val_loss: 0.3711
Epoch 20/20
1452/1452            0s 260ms/step -
accuracy: 0.8242 - loss: 0.5484
Epoch 20: val_loss improved from 0.37107 to 0.35875, saving model to
/home/ryan/skf_save/model_4.keras
1452/1452            474s 326ms/step
- accuracy: 0.8251 - loss: 0.5467 - val_accuracy: 0.8820 - val_loss: 0.3587
363/363             93s 255ms/step -
accuracy: 0.8811 - loss: 0.3564
[0.8826087117195129, 0.8818338513374329, 0.8760170340538025, 0.8801498413085938,
```

```
0.8810538649559021]
[0.34899380803108215, 0.3553321957588196, 0.37334582209587097,
0.3736894130706787, 0.3564313054084778]
```

[136]:
```
print(val_acc)
print(val_loss)
```

```
[0.8826087117195129, 0.8818338513374329, 0.8760170340538025, 0.8801498413085938,
0.8810538649559021]
[0.34899380803108215, 0.3553321957588196, 0.37334582209587097,
0.3736894130706787, 0.3564313054084778]
```