In [10]:

```
import tensorflow as tf
from tensorflow.keras.applications import EfficientNetB0
from tensorflow.keras.preprocessing.image import ImageDataGenerator
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense, Dropout, BatchNormalization
from tensorflow.keras.optimizers import Adam
from tensorflow.keras.losses import CategoricalCrossentropy
from tensorflow.keras.callbacks import EarlyStopping, ReduceLROnPlateau

# Directories where your data is stored
train_dir = r'C:\Users\Abhishek\Downloads\pot\train'
validation_dir = r'C:\Users\Abhishek\Downloads\pot\val'
test_dir = r'C:\Users\Abhishek\Downloads\pot\test'

# Define constants
IMG_SIZE = 224
BATCH_SIZE = 16  # Reduced batch size
NUM_CLASSES = 3  # Number of classes in your dataset
EPOCHS = 100

# Generate batches of tensor image data with real-time data augmentation
datagen = ImageDataGenerator(
    rescale=1./255,
    horizontal_flip=True,
    vertical_flip=True)

train_generator = datagen.flow_from_directory(
    train_dir,
    target_size=(IMG_SIZE, IMG_SIZE),
    batch_size=BATCH_SIZE,
    class_mode='categorical')

validation_generator = datagen.flow_from_directory(
    validation_dir,
    target_size=(IMG_SIZE, IMG_SIZE),
    batch_size=BATCH_SIZE,
    class_mode='categorical')

test_generator = datagen.flow_from_directory(
    test_dir,
    target_size=(IMG_SIZE, IMG_SIZE),
    batch_size=BATCH_SIZE,
    class_mode='categorical')

# Load base model
base_model = EfficientNetB0(weights='imagenet', include_top=False, input_shape=(IMG_

# Add a new top layer
x = base_model.output
x = tf.keras.layers.GlobalAveragePooling2D()(x)
x = Dense(512, activation='relu')(x)  # Reduced the number of neurons
x = Dropout(0.2)(x)  # Add dropout layer to reduce overfitting
x = BatchNormalization()(x)
predictions = Dense(NUM_CLASSES, activation='softmax')(x)

# This is the model we will train
model = tf.keras.models.Model(inputs=base_model.input, outputs=predictions)

# Freeze the base model
for layer in base_model.layers:
    layer.trainable = False
```

```
# Compile the model
model.compile(optimizer=Adam(lr=0.001), loss=CategoricalCrossentropy(), metrics=['ac

# Define callbacks
early_stopping = EarlyStopping(monitor='val_loss', patience=10, restore_best_weights
reduce_lr = ReduceLROnPlateau(monitor='val_loss', factor=0.2, patience=5, min_lr=0.0

# Train the model
history = model.fit(
    train_generator,
    epochs=EPOCHS,
    validation_data=validation_generator,
    callbacks=[early_stopping, reduce_lr])

# Unfreeze the layers of the base model and fine-tune the entire model
for layer in base_model.layers:
    layer.trainable = True

# Recompile the model
model.compile(optimizer=Adam(lr=0.00001), loss=CategoricalCrossentropy(), metrics=['

# Continue training the model
history_fine_tuning = model.fit(
    train_generator,
    epochs=EPOCHS,
    validation_data=validation_generator,
    callbacks=[early_stopping, reduce_lr])

# Evaluate the model on the test data after fine-tuning
# Evaluate the model on the test data after fine-tuning
score = model.evaluate(test_generator)
print(f'Test loss: {score[0]} / Test accuracy: {score[1]}')
```

```
Found 900 images belonging to 3 classes.
Found 300 images belonging to 3 classes.
Found 949 images belonging to 3 classes.
WARNING:absl:`lr` is deprecated, please use `learning_rate` instead, or use the lega
cy optimizer, e.g.,tf.keras.optimizers.legacy.Adam.
Epoch 1/100
57/57 [==============================] - 36s 533ms/step - loss: 1.2071 - accuracy:
0.4033 - val_loss: 1.0388 - val_accuracy: 0.4333 - lr: 0.0010
Epoch 2/100
57/57 [==============================] - 28s 496ms/step - loss: 1.1035 - accuracy:
0.4467 - val_loss: 1.0384 - val_accuracy: 0.4333 - lr: 0.0010
Epoch 3/100
57/57 [==============================] - 38s 664ms/step - loss: 1.0913 - accuracy:
0.4378 - val_loss: 0.9908 - val_accuracy: 0.4333 - lr: 0.0010
Epoch 4/100
57/57 [==============================] - 39s 688ms/step - loss: 1.0721 - accuracy:
0.4422 - val_loss: 1.1354 - val_accuracy: 0.4333 - lr: 0.0010
Epoch 5/100
57/57 [==============================] - 38s 674ms/step - loss: 1.0405 - accuracy:
0.4444 - val_loss: 1.0219 - val_accuracy: 0.4333 - lr: 0.0010
Epoch 6/100
57/57 [==============================] - 40s 700ms/step - loss: 1.0243 - accuracy:
0.4467 - val_loss: 1.0117 - val_accuracy: 0.4333 - lr: 0.0010
Epoch 7/100
57/57 [==============================] - 42s 742ms/step - loss: 1.0383 - accuracy:
0.4378 - val_loss: 1.0210 - val_accuracy: 0.4333 - lr: 0.0010
Epoch 8/100
57/57 [==============================] - 42s 732ms/step - loss: 1.0081 - accuracy:
0.4678 - val_loss: 0.9914 - val_accuracy: 0.4333 - lr: 0.0010
Epoch 9/100
57/57 [==============================] - 38s 673ms/step - loss: 1.0169 - accuracy:
0.4511 - val_loss: 1.0437 - val_accuracy: 0.4333 - lr: 2.0000e-04
Epoch 10/100
```

```
57/57 [==============================] - 38s 666ms/step - loss: 1.0094 - accuracy:
0.4378 - val_loss: 1.0011 - val_accuracy: 0.6033 - lr: 2.0000e-04
Epoch 11/100
57/57 [==============================] - 38s 667ms/step - loss: 0.9855 - accuracy:
0.4567 - val_loss: 1.0156 - val_accuracy: 0.4333 - lr: 2.0000e-04
Epoch 12/100
57/57 [==============================] - 39s 680ms/step - loss: 1.0079 - accuracy:
0.4467 - val_loss: 1.0047 - val_accuracy: 0.4333 - lr: 2.0000e-04
Epoch 13/100
57/57 [==============================] - 42s 748ms/step - loss: 0.9996 - accuracy:
0.4567 - val_loss: 1.0037 - val_accuracy: 0.4333 - lr: 2.0000e-04
WARNING:absl:`lr` is deprecated, please use `learning_rate` instead, or use the lega
cy optimizer, e.g.,tf.keras.optimizers.legacy.Adam.
Epoch 1/100
57/57 [==============================] - 146s 2s/step - loss: 0.3686 - accuracy: 0.8
667 - val_loss: 2.5280 - val_accuracy: 0.4333 - lr: 0.0010
Epoch 2/100
57/57 [==============================] - 164s 3s/step - loss: 0.1429 - accuracy: 0.9
533 - val_loss: 2.3595 - val_accuracy: 0.4333 - lr: 0.0010
Epoch 3/100
57/57 [==============================] - 190s 3s/step - loss: 0.0944 - accuracy: 0.9
756 - val_loss: 3.6975 - val_accuracy: 0.4333 - lr: 0.0010
Epoch 4/100
57/57 [==============================] - 198s 3s/step - loss: 0.0679 - accuracy: 0.9
722 - val_loss: 1.4277 - val_accuracy: 0.5033 - lr: 0.0010
Epoch 5/100
57/57 [==============================] - 183s 3s/step - loss: 0.0631 - accuracy: 0.9
811 - val_loss: 1.0940 - val_accuracy: 0.4333 - lr: 0.0010
Epoch 6/100
57/57 [==============================] - 171s 3s/step - loss: 0.1919 - accuracy: 0.9
467 - val_loss: 23.7631 - val_accuracy: 0.4333 - lr: 0.0010
Epoch 7/100
57/57 [==============================] - 185s 3s/step - loss: 0.0961 - accuracy: 0.9
700 - val_loss: 2.5525 - val_accuracy: 0.4333 - lr: 0.0010
Epoch 8/100
57/57 [==============================] - 212s 4s/step - loss: 0.0303 - accuracy: 0.9
900 - val_loss: 2.4992 - val_accuracy: 0.4333 - lr: 0.0010
Epoch 9/100
57/57 [==============================] - 204s 4s/step - loss: 0.0509 - accuracy: 0.9
856 - val_loss: 2.9891 - val_accuracy: 0.3467 - lr: 0.0010
Epoch 10/100
57/57 [==============================] - 179s 3s/step - loss: 0.0482 - accuracy: 0.9
867 - val_loss: 71.6064 - val_accuracy: 0.4333 - lr: 0.0010
Epoch 11/100
57/57 [==============================] - 178s 3s/step - loss: 0.0204 - accuracy: 0.9
956 - val_loss: 3.7053 - val_accuracy: 0.3267 - lr: 2.0000e-04
Epoch 12/100
57/57 [==============================] - 173s 3s/step - loss: 0.0103 - accuracy: 0.9
989 - val_loss: 7.4499 - val_accuracy: 0.1333 - lr: 2.0000e-04
Epoch 13/100
57/57 [==============================] - 174s 3s/step - loss: 0.0428 - accuracy: 0.9
944 - val_loss: 4.5396 - val_accuracy: 0.1367 - lr: 2.0000e-04
Epoch 14/100
57/57 [==============================] - 185s 3s/step - loss: 0.0069 - accuracy: 1.0
000 - val_loss: 0.0882 - val_accuracy: 0.9667 - lr: 2.0000e-04
Epoch 15/100
57/57 [==============================] - 237s 4s/step - loss: 0.0371 - accuracy: 0.9
911 - val_loss: 5.2000 - val_accuracy: 0.1333 - lr: 2.0000e-04
Epoch 16/100
57/57 [==============================] - 243s 4s/step - loss: 0.0203 - accuracy: 0.9
956 - val_loss: 2.4562 - val_accuracy: 0.3400 - lr: 2.0000e-04
Epoch 17/100
57/57 [==============================] - 233s 4s/step - loss: 0.0273 - accuracy: 0.9
956 - val_loss: 4.6832 - val_accuracy: 0.1633 - lr: 2.0000e-04
Epoch 18/100
57/57 [==============================] - 228s 4s/step - loss: 0.0096 - accuracy: 0.9
978 - val_loss: 2.7823 - val_accuracy: 0.1767 - lr: 2.0000e-04
Epoch 19/100
57/57 [==============================] - 226s 4s/step - loss: 0.0186 - accuracy: 0.9
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956 - val_loss: 1.6098 - val_accuracy: 0.5867 - lr: 2.0000e-04
Epoch 20/100
57/57 [==============================] - 229s 4s/step - loss: 0.0258 - accuracy: 0.9
956 - val_loss: 0.5379 - val_accuracy: 0.8033 - lr: 4.0000e-05
Epoch 21/100
57/57 [==============================] - 252s 4s/step - loss: 0.0246 - accuracy: 0.9
967 - val_loss: 1.2257 - val_accuracy: 0.6267 - lr: 4.0000e-05
Epoch 22/100
57/57 [==============================] - 279s 5s/step - loss: 0.0049 - accuracy: 1.0
000 - val_loss: 0.2986 - val_accuracy: 0.9233 - lr: 4.0000e-05
Epoch 23/100
57/57 [==============================] - 228s 4s/step - loss: 0.0059 - accuracy: 0.9
989 - val_loss: 0.0744 - val_accuracy: 0.9733 - lr: 4.0000e-05
Epoch 24/100
57/57 [==============================] - 229s 4s/step - loss: 0.0077 - accuracy: 0.9
978 - val_loss: 0.0392 - val_accuracy: 0.9833 - lr: 4.0000e-05
Epoch 25/100
57/57 [==============================] - 255s 4s/step - loss: 0.0027 - accuracy: 1.0
000 - val_loss: 0.0121 - val_accuracy: 0.9967 - lr: 4.0000e-05
Epoch 26/100
57/57 [==============================] - 255s 4s/step - loss: 0.0092 - accuracy: 0.9
978 - val_loss: 0.0274 - val_accuracy: 0.9967 - lr: 4.0000e-05
Epoch 27/100
57/57 [==============================] - 274s 5s/step - loss: 0.0101 - accuracy: 0.9
989 - val_loss: 0.0180 - val_accuracy: 0.9933 - lr: 4.0000e-05
Epoch 28/100
57/57 [==============================] - 242s 4s/step - loss: 0.0033 - accuracy: 1.0
000 - val_loss: 0.0073 - val_accuracy: 0.9967 - lr: 4.0000e-05
Epoch 29/100
57/57 [==============================] - 241s 4s/step - loss: 0.0032 - accuracy: 1.0
000 - val_loss: 0.0263 - val_accuracy: 0.9933 - lr: 4.0000e-05
Epoch 30/100
57/57 [==============================] - 238s 4s/step - loss: 0.0196 - accuracy: 0.9
978 - val_loss: 0.0170 - val_accuracy: 0.9967 - lr: 4.0000e-05
Epoch 31/100
57/57 [==============================] - 208s 4s/step - loss: 0.0368 - accuracy: 0.9
933 - val_loss: 0.0895 - val_accuracy: 0.9700 - lr: 4.0000e-05
Epoch 32/100
57/57 [==============================] - 213s 4s/step - loss: 0.0289 - accuracy: 0.9
967 - val_loss: 0.0449 - val_accuracy: 0.9900 - lr: 4.0000e-05
Epoch 33/100
57/57 [==============================] - 255s 5s/step - loss: 0.0031 - accuracy: 1.0
000 - val_loss: 0.0368 - val_accuracy: 0.9933 - lr: 4.0000e-05
Epoch 34/100
57/57 [==============================] - 269s 5s/step - loss: 0.0078 - accuracy: 0.9
989 - val_loss: 0.0071 - val_accuracy: 0.9967 - lr: 1.0000e-05
Epoch 35/100
57/57 [==============================] - 263s 5s/step - loss: 0.0056 - accuracy: 0.9
989 - val_loss: 0.0034 - val_accuracy: 1.0000 - lr: 1.0000e-05
Epoch 36/100
57/57 [==============================] - 270s 5s/step - loss: 0.0161 - accuracy: 0.9
967 - val_loss: 0.0303 - val_accuracy: 0.9967 - lr: 1.0000e-05
Epoch 37/100
57/57 [==============================] - 304s 5s/step - loss: 0.0067 - accuracy: 1.0
000 - val_loss: 0.0042 - val_accuracy: 1.0000 - lr: 1.0000e-05
Epoch 38/100
57/57 [==============================] - 316s 6s/step - loss: 0.0061 - accuracy: 0.9
989 - val_loss: 0.0026 - val_accuracy: 1.0000 - lr: 1.0000e-05
Epoch 39/100
57/57 [==============================] - 327s 6s/step - loss: 0.0054 - accuracy: 0.9
989 - val_loss: 0.0043 - val_accuracy: 1.0000 - lr: 1.0000e-05
Epoch 40/100
57/57 [==============================] - 318s 6s/step - loss: 0.0064 - accuracy: 0.9
978 - val_loss: 0.0290 - val_accuracy: 0.9967 - lr: 1.0000e-05
Epoch 41/100
57/57 [==============================] - 317s 6s/step - loss: 0.0061 - accuracy: 0.9
989 - val_loss: 0.0038 - val_accuracy: 1.0000 - lr: 1.0000e-05
Epoch 42/100
57/57 [==============================] - 348s 6s/step - loss: 0.0040 - accuracy: 1.0
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000 - val_loss: 0.0049 - val_accuracy: 1.0000 - lr: 1.0000e-05
Epoch 43/100
57/57 [==============================] - 355s 6s/step - loss: 0.0051 - accuracy: 0.9
989 - val_loss: 0.0031 - val_accuracy: 1.0000 - lr: 1.0000e-05
Epoch 44/100
57/57 [==============================] - 361s 6s/step - loss: 0.0047 - accuracy: 1.0
000 - val_loss: 0.0264 - val_accuracy: 0.9967 - lr: 1.0000e-05
Epoch 45/100
57/57 [==============================] - 351s 6s/step - loss: 0.0091 - accuracy: 0.9
967 - val_loss: 0.0059 - val_accuracy: 0.9967 - lr: 1.0000e-05
Epoch 46/100
57/57 [==============================] - 187s 3s/step - loss: 0.0035 - accuracy: 1.0
000 - val_loss: 0.0019 - val_accuracy: 1.0000 - lr: 1.0000e-05
Epoch 47/100
57/57 [==============================] - 348s 6s/step - loss: 0.0036 - accuracy: 1.0
000 - val_loss: 0.0018 - val_accuracy: 1.0000 - lr: 1.0000e-05
Epoch 48/100
57/57 [==============================] - 366s 6s/step - loss: 0.0048 - accuracy: 0.9
989 - val_loss: 0.0044 - val_accuracy: 1.0000 - lr: 1.0000e-05
Epoch 49/100
57/57 [==============================] - 194s 3s/step - loss: 0.0038 - accuracy: 1.0
000 - val_loss: 0.0031 - val_accuracy: 1.0000 - lr: 1.0000e-05
Epoch 50/100
57/57 [==============================] - 180s 3s/step - loss: 0.0042 - accuracy: 1.0
000 - val_loss: 0.0056 - val_accuracy: 0.9967 - lr: 1.0000e-05
Epoch 51/100
57/57 [==============================] - 179s 3s/step - loss: 0.0061 - accuracy: 0.9
989 - val_loss: 0.0270 - val_accuracy: 0.9967 - lr: 1.0000e-05
Epoch 52/100
57/57 [==============================] - 186s 3s/step - loss: 0.0098 - accuracy: 0.9
989 - val_loss: 0.0299 - val_accuracy: 0.9967 - lr: 1.0000e-05
Epoch 53/100
57/57 [==============================] - 243s 4s/step - loss: 0.0028 - accuracy: 1.0
000 - val_loss: 0.0025 - val_accuracy: 1.0000 - lr: 1.0000e-05
Epoch 54/100
57/57 [==============================] - 237s 4s/step - loss: 0.0031 - accuracy: 1.0
000 - val_loss: 0.0017 - val_accuracy: 1.0000 - lr: 1.0000e-05
Epoch 55/100
57/57 [==============================] - 241s 4s/step - loss: 0.0231 - accuracy: 0.9
978 - val_loss: 0.0062 - val_accuracy: 1.0000 - lr: 1.0000e-05
Epoch 56/100
57/57 [==============================] - 241s 4s/step - loss: 0.0267 - accuracy: 0.9
978 - val_loss: 0.0051 - val_accuracy: 0.9967 - lr: 1.0000e-05
Epoch 57/100
57/57 [==============================] - 306s 5s/step - loss: 0.0089 - accuracy: 0.9
978 - val_loss: 0.0045 - val_accuracy: 0.9967 - lr: 1.0000e-05
Epoch 58/100
57/57 [==============================] - 314s 6s/step - loss: 0.0033 - accuracy: 1.0
000 - val_loss: 0.0027 - val_accuracy: 1.0000 - lr: 1.0000e-05
Epoch 59/100
57/57 [==============================] - 309s 5s/step - loss: 0.0045 - accuracy: 0.9
989 - val_loss: 0.0026 - val_accuracy: 1.0000 - lr: 1.0000e-05
Epoch 60/100
57/57 [==============================] - 280s 5s/step - loss: 0.0028 - accuracy: 1.0
000 - val_loss: 0.0292 - val_accuracy: 0.9967 - lr: 1.0000e-05
Epoch 61/100
57/57 [==============================] - 186s 3s/step - loss: 0.0044 - accuracy: 1.0
000 - val_loss: 0.0018 - val_accuracy: 1.0000 - lr: 1.0000e-05
Epoch 62/100
57/57 [==============================] - 191s 3s/step - loss: 0.0028 - accuracy: 1.0
000 - val_loss: 0.0279 - val_accuracy: 0.9967 - lr: 1.0000e-05
Epoch 63/100
57/57 [==============================] - 186s 3s/step - loss: 0.0034 - accuracy: 1.0
000 - val_loss: 0.0030 - val_accuracy: 1.0000 - lr: 1.0000e-05
Epoch 64/100
57/57 [==============================] - 199s 4s/step - loss: 0.0028 - accuracy: 1.0
000 - val_loss: 0.0034 - val_accuracy: 1.0000 - lr: 1.0000e-05
60/60 [==============================] - 63s 1s/step - loss: 0.0035 - accuracy: 0.99
```

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89
Test loss: 0.003513235365971923 / Test accuracy: 0.9989462494850159
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In [ ]: