

```
from google.colab import drive
drive.mount('/content/drive')
```

Mounted at /content/drive

```
import os, pathlib, shutil
import numpy as np
import matplotlib.pyplot as plt
import itertools
from sklearn.metrics import classification_report, confusion_matrix
import tensorflow as tf
from tensorflow.keras import layers, models, callbacks, applications

IMG_SIZE = (224, 224)
BATCH_SIZE = 32
SEED = 42
AUTOTUNE = tf.data.AUTOTUNE
```

```
TRAIN_DIR = "/content/drive/MyDrive/bird_drone_project/classification_dataset/train-20251113T160913Z-1-001/train"
VALID_DIR = "/content/drive/MyDrive/bird_drone_project/classification_dataset/valid-20251113T160916Z-1-001/valid"
TEST_DIR = "/content/drive/MyDrive/bird_drone_project/classification_dataset/test-20251113T154837Z-1-001/test"

train_ds = tf.keras.preprocessing.image_dataset_from_directory(
    TRAIN_DIR,
    label_mode='binary',
    image_size=IMG_SIZE,
    batch_size=BATCH_SIZE,
    seed=42,
    shuffle=True
)

val_ds = tf.keras.preprocessing.image_dataset_from_directory(
    VALID_DIR,
    label_mode='binary',
    image_size=IMG_SIZE,
    batch_size=BATCH_SIZE,
    seed=42,
    shuffle=False
)

test_ds = tf.keras.preprocessing.image_dataset_from_directory(
    TEST_DIR,
    label_mode='binary',
    image_size=IMG_SIZE,
    batch_size=BATCH_SIZE,
    seed=42,
    shuffle=False
)
```

```
Found 2662 files belonging to 2 classes.
Found 442 files belonging to 2 classes.
Found 215 files belonging to 2 classes.
```

```
data_augmentation = tf.keras.Sequential([
    layers.RandomFlip('horizontal'),
    layers.RandomRotation(0.12),
    layers.RandomZoom(0.1),
    layers.RandomContrast(0.1),
    layers.RandomTranslation(0.05, 0.05)
], name='data_augmentation')
```

```
def build_custom_cnn(input_shape=IMG_SIZE + (3,)):
    inputs = layers.Input(shape=input_shape)

    x = data_augmentation(inputs)
    x = layers.Rescaling(1./255)(x)

    x = layers.Conv2D(32, 3, activation='relu', padding='same')(x)
```

```

x = layers.BatchNormalization()(x)
x = layers.MaxPooling2D()(x)

x = layers.Conv2D(64, 3, activation='relu', padding='same')(x)
x = layers.BatchNormalization()(x)
x = layers.MaxPooling2D()(x)

x = layers.Conv2D(128, 3, activation='relu', padding='same')(x)
x = layers.BatchNormalization()(x)
x = layers.MaxPooling2D()(x)

x = layers.GlobalAveragePooling2D()(x)
x = layers.Dropout(0.4)(x)

x = layers.Dense(64, activation='relu')(x)
x = layers.BatchNormalization()(x)
x = layers.Dropout(0.3)(x)

outputs = layers.Dense(1, activation='sigmoid')(x)

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

return model

custom_model = build_custom_cnn()
custom_model.summary()

```

Model: "functional_4"

Layer (type)	Output Shape	Param #
input_layer_3 (InputLayer)	(None, 224, 224, 3)	0
data_augmentation (Sequential)	(None, 224, 224, 3)	0
rescaling (Rescaling)	(None, 224, 224, 3)	0
conv2d_8 (Conv2D)	(None, 224, 224, 32)	896
batch_normalization_6 (BatchNormalization)	(None, 224, 224, 32)	128
max_pooling2d_8 (MaxPooling2D)	(None, 112, 112, 32)	0
conv2d_9 (Conv2D)	(None, 112, 112, 64)	18,496
batch_normalization_7 (BatchNormalization)	(None, 112, 112, 64)	256
max_pooling2d_9 (MaxPooling2D)	(None, 56, 56, 64)	0
conv2d_10 (Conv2D)	(None, 56, 56, 128)	73,856
batch_normalization_8 (BatchNormalization)	(None, 56, 56, 128)	512
max_pooling2d_10 (MaxPooling2D)	(None, 28, 28, 128)	0
global_average_pooling2d (GlobalAveragePooling2D)	(None, 128)	0
dropout_2 (Dropout)	(None, 128)	0
dense_6 (Dense)	(None, 64)	8,256
batch_normalization_9 (BatchNormalization)	(None, 64)	256
dropout_3 (Dropout)	(None, 64)	0
dense_7 (Dense)	(None, 1)	65

Total params: 102,721 (401.25 KB)

Trainable params: 102,145 (399.00 KB)

Non-trainable params: 576 (2.25 KB)

```

from tensorflow.keras.callbacks import EarlyStopping, ModelCheckpoint, ReduceLROnPlateau

callbacks =

```

```
EarlyStopping(monitor='val_loss', patience=6, restore_best_weights=True),
ModelCheckpoint("/content/best_custom_cnn.h5", monitor='val_loss', save_best_only=True),
ReduceLROnPlateau(monitor='val_loss', factor=0.5, patience=3)
]
```

```
from tensorflow.keras.callbacks import EarlyStopping, ModelCheckpoint
callbacks_cnn = [
    EarlyStopping(monitor='val_loss', patience=6, restore_best_weights=True),
    ModelCheckpoint("best_cnn_model.h5", monitor='val_loss', save_best_only=True)
]
```

```
custom_model.compile(
    optimizer='adam',
    loss='binary_crossentropy',
    metrics=['accuracy']
)
```

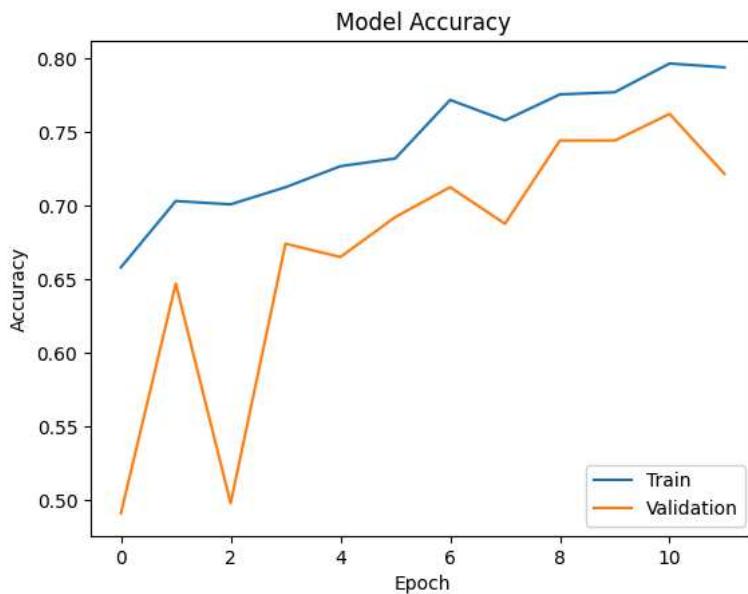
```
EPOCHS = 12

history_cnn = custom_model.fit(
    train_ds,
    validation_data=val_ds,
    epochs=EPOCHS,
    callbacks=callbacks_cnn
)
```

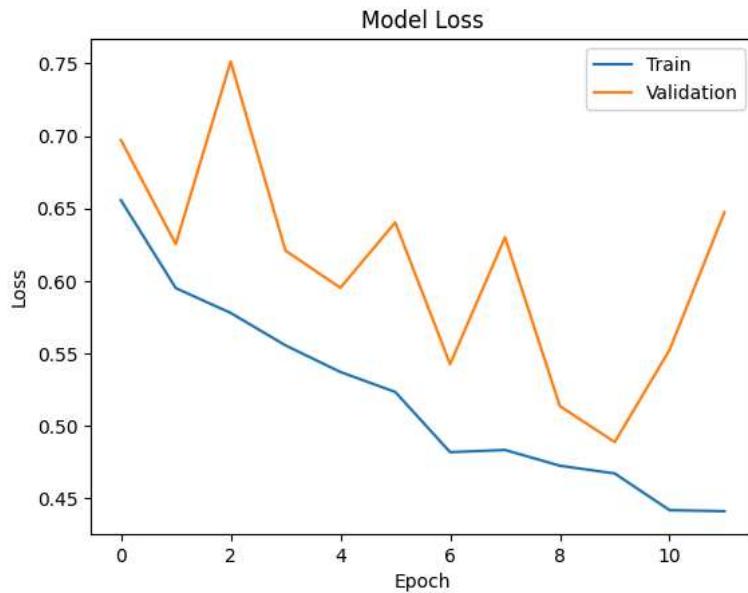
```
Epoch 1/12
84/84 ━━━━━━━━━━ 0s 6s/step - accuracy: 0.6449 - loss: 0.7010WARNING:absl:You are saving your model as an HDF5 file vi
84/84 ━━━━━━━━━━ 589s 7s/step - accuracy: 0.6451 - loss: 0.7005 - val_accuracy: 0.4910 - val_loss: 0.6972
Epoch 2/12
84/84 ━━━━━━━━━━ 0s 6s/step - accuracy: 0.7144 - loss: 0.5808WARNING:absl:You are saving your model as an HDF5 file vi
84/84 ━━━━━━━━━━ 531s 6s/step - accuracy: 0.7143 - loss: 0.5810 - val_accuracy: 0.6471 - val_loss: 0.6254
Epoch 3/12
84/84 ━━━━━━━━━━ 508s 6s/step - accuracy: 0.7031 - loss: 0.5748 - val_accuracy: 0.4977 - val_loss: 0.7514
Epoch 4/12
84/84 ━━━━━━━━━━ 0s 6s/step - accuracy: 0.7070 - loss: 0.5492WARNING:absl:You are saving your model as an HDF5 file vi
84/84 ━━━━━━━━━━ 563s 6s/step - accuracy: 0.7070 - loss: 0.5493 - val_accuracy: 0.6742 - val_loss: 0.6209
Epoch 5/12
84/84 ━━━━━━━━━━ 0s 6s/step - accuracy: 0.7299 - loss: 0.5392WARNING:absl:You are saving your model as an HDF5 file vi
84/84 ━━━━━━━━━━ 575s 6s/step - accuracy: 0.7298 - loss: 0.5391 - val_accuracy: 0.6652 - val_loss: 0.5952
Epoch 6/12
84/84 ━━━━━━━━━━ 527s 6s/step - accuracy: 0.7467 - loss: 0.5026 - val_accuracy: 0.6923 - val_loss: 0.6404
Epoch 7/12
84/84 ━━━━━━━━━━ 0s 6s/step - accuracy: 0.7518 - loss: 0.4852WARNING:absl:You are saving your model as an HDF5 file vi
84/84 ━━━━━━━━━━ 526s 6s/step - accuracy: 0.7520 - loss: 0.4852 - val_accuracy: 0.7127 - val_loss: 0.5426
Epoch 8/12
84/84 ━━━━━━━━━━ 563s 6s/step - accuracy: 0.7636 - loss: 0.4733 - val_accuracy: 0.6878 - val_loss: 0.6301
Epoch 9/12
84/84 ━━━━━━━━━━ 0s 6s/step - accuracy: 0.7876 - loss: 0.4590WARNING:absl:You are saving your model as an HDF5 file vi
84/84 ━━━━━━━━━━ 569s 6s/step - accuracy: 0.7874 - loss: 0.4592 - val_accuracy: 0.7443 - val_loss: 0.5136
Epoch 10/12
84/84 ━━━━━━━━━━ 0s 6s/step - accuracy: 0.7749 - loss: 0.4623WARNING:absl:You are saving your model as an HDF5 file vi
84/84 ━━━━━━━━━━ 534s 6s/step - accuracy: 0.7749 - loss: 0.4624 - val_accuracy: 0.7443 - val_loss: 0.4888
Epoch 11/12
84/84 ━━━━━━━━━━ 526s 6s/step - accuracy: 0.7887 - loss: 0.4540 - val_accuracy: 0.7624 - val_loss: 0.5525
Epoch 12/12
84/84 ━━━━━━━━━━ 523s 6s/step - accuracy: 0.7994 - loss: 0.4417 - val_accuracy: 0.7217 - val_loss: 0.6474
```

```
import matplotlib.pyplot as plt

# Accuracy plot
plt.plot(history_cnn.history['accuracy'])
plt.plot(history_cnn.history['val_accuracy'])
plt.title('Model Accuracy')
plt.ylabel('Accuracy')
plt.xlabel('Epoch')
plt.legend(['Train', 'Validation'], loc='lower right')
plt.show()
```



```
plt.plot(history_cnn.history['loss'])
plt.plot(history_cnn.history['val_loss'])
plt.title('Model Loss')
plt.ylabel('Loss')
plt.xlabel('Epoch')
plt.legend(['Train', 'Validation'], loc='upper right')
plt.show()
```



```
model_t1.save("/content/best_model.keras")
```

```
from tensorflow.keras.preprocessing.image import ImageDataGenerator

# Training data generator with augmentation
train_datagen = ImageDataGenerator(
    rescale=1./255,
    rotation_range=20,
    width_shift_range=0.2,
    height_shift_range=0.2,
    horizontal_flip=True
)

# Validation data generator (just rescale)
valid_datagen = ImageDataGenerator(rescale=1./255)
```

```
# Load training data
train = train_datagen.flow_from_directory(
    '/content/drive/MyDrive/bird_drone_project/classification_dataset/train-20251113T160913Z-1-001/train',   # change to your train directory
    target_size=(224, 224),
    batch_size=32,
    class_mode='categorical'
)

# Load validation data
valid = valid_datagen.flow_from_directory(
    '/content/drive/MyDrive/bird_drone_project/classification_dataset/valid-20251113T160916Z-1-001/valid',   # change to your validation directory
    target_size=(224, 224),
    batch_size=32,
    class_mode='categorical'
)
```

```
Found 2662 images belonging to 2 classes.
Found 442 images belonging to 2 classes.
```

```
y_pred = custom_model.predict(test_ds)
y_pred = (y_pred > 0.5).astype(int)
```

```
7/7 ━━━━━━━━━━ 10s 1s/step
```

```
!ls -R /content/drive/MyDrive
!ls -R /content/drive/MyDrive/bird_drone_project
```

```
pic_085.jpg.rf.1bfd82dac9e3f9d2ddd0de2bd1d5aef6.jpg
```

```
pic_085.jpg.rf.8a3c3a5eb8f4d8fa50b127098cde2eb6.jpg
pic_086.jpg.rf.03729618c5e84a01b9b59fadaa571846.jpg
pic_086.jpg.rf.328afdf7f785e4de20d0a0b2c3718698d.jpg
pic_087.jpg.rf.5ed9100876f7df5d3f284826f66f0064.jpg
pic_087.jpg.rf.cf8eced9a302a869a87f9510ecc71594.jpg
pic_088.jpg.rf.483f4e04d42b39d2f6ffdd866f7d454ba.jpg
pic_088.jpg.rf.9673459b13aed427a15926341d615ee.jpg
pic_090.jpg.rf.07cbe05d5590ea3cf48e0550e891a95.jpg
```

```
from tensorflow.keras.layers import GlobalAveragePooling2D, Dense
from tensorflow.keras.models import Model
```

```
from tensorflow.keras.applications import MobileNetV2
from tensorflow.keras.layers import GlobalAveragePooling2D, Dense
from tensorflow.keras.models import Model

# Load base model
base_model = MobileNetV2(
    input_shape=(224, 224, 3),
    include_top=False,
    weights='imagenet'
)

base_model.trainable = False # freeze weights

# Add custom layers
x = base_model.output
x = GlobalAveragePooling2D()(x)
x = Dense(128, activation='relu')(x)
outputs = Dense(2, activation='softmax')(x) # For 2 classes

model_t1 = Model(inputs=base_model.input, outputs=outputs)

# Compile
model_t1.compile(
    optimizer='adam',
    loss='categorical_crossentropy', # Because 2 classes
    metrics=['accuracy']
)
```

```
history_t1 = model_t1.fit(
    train,
    validation_data=valid,
    epochs=10
)
```

```
Epoch 1/10
84/84 177s 2s/step - accuracy: 0.8756 - loss: 0.3075 - val_accuracy: 0.9615 - val_loss: 0.0922
Epoch 2/10
84/84 166s 2s/step - accuracy: 0.9675 - loss: 0.0775 - val_accuracy: 0.9593 - val_loss: 0.0965
Epoch 3/10
84/84 167s 2s/step - accuracy: 0.9854 - loss: 0.0431 - val_accuracy: 0.9751 - val_loss: 0.0771
Epoch 4/10
84/84 168s 2s/step - accuracy: 0.9861 - loss: 0.0389 - val_accuracy: 0.9729 - val_loss: 0.0728
Epoch 5/10
84/84 167s 2s/step - accuracy: 0.9874 - loss: 0.0287 - val_accuracy: 0.9683 - val_loss: 0.0750
Epoch 6/10
84/84 168s 2s/step - accuracy: 0.9814 - loss: 0.0401 - val_accuracy: 0.9683 - val_loss: 0.0860
Epoch 7/10
84/84 168s 2s/step - accuracy: 0.9856 - loss: 0.0354 - val_accuracy: 0.9661 - val_loss: 0.1027
Epoch 8/10
84/84 168s 2s/step - accuracy: 0.9909 - loss: 0.0280 - val_accuracy: 0.9593 - val_loss: 0.1189
Epoch 9/10
84/84 171s 2s/step - accuracy: 0.9887 - loss: 0.0354 - val_accuracy: 0.9593 - val_loss: 0.1302
Epoch 10/10
84/84 176s 2s/step - accuracy: 0.9828 - loss: 0.0490 - val_accuracy: 0.9751 - val_loss: 0.0700
```

```
test_datagen = ImageDataGenerator(rescale=1./255)

test = test_datagen.flow_from_directory(
    '/content/drive/MyDrive/bird_drone_project/classification_dataset/test-20251113T154837Z-1-001/test', # <-- change
    target_size=(224, 224),
    batch_size=32,
    class_mode='categorical',
```

```
shuffle=False          # IMPORTANT for correct predictions
)
```

Found 215 images belonging to 2 classes.

```
import numpy as np
from sklearn.metrics import confusion_matrix, classification_report

# Predictions
t_predictions = model_t1.predict(test)
y_pred = np.argmax(t_predictions, axis=1)
y_true = test.classes

# Reports
print(confusion_matrix(y_true, y_pred))
print(classification_report(y_true, y_pred))
```

7/7 ━━━━━━━━ 14s 2s/step
[[119 2]
 [4 90]]

	precision	recall	f1-score	support
0	0.97	0.98	0.98	121
1	0.98	0.96	0.97	94
accuracy			0.97	215
macro avg	0.97	0.97	0.97	215
weighted avg	0.97	0.97	0.97	215

```
t_predictions = model_t1.predict(test)

# Convert softmax probabilities to class labels
y_pred = np.argmax(t_predictions, axis=1)
y_true = test.classes

from sklearn.metrics import confusion_matrix, classification_report

print(confusion_matrix(y_true, y_pred))
print(classification_report(y_true, y_pred, target_names=["Bird", "Drone"]))
```

7/7 ━━━━━━━━ 19s 3s/step
[[119 2]
 [4 90]]

	precision	recall	f1-score	support
Bird	0.97	0.98	0.98	121
Drone	0.98	0.96	0.97	94
accuracy			0.97	215
macro avg	0.97	0.97	0.97	215
weighted avg	0.97	0.97	0.97	215

```
t_predictions = model_t1.predict(test)

# Convert softmax probabilities to class labels
y_pred = np.argmax(t_predictions, axis=1)
y_true = test.classes

from sklearn.metrics import confusion_matrix, classification_report

print(confusion_matrix(y_true, y_pred))
print(classification_report(y_true, y_pred, target_names=["Bird", "Drone"]))
```

7/7 ━━━━━━━━ 19s 2s/step
[[119 2]
 [4 90]]

	precision	recall	f1-score	support
Bird	0.97	0.98	0.98	121
Drone	0.98	0.96	0.97	94
accuracy			0.97	215
macro avg	0.97	0.97	0.97	215

```
weighted avg      0.97      0.97      0.97      215
```

```
model_tl.save("bird_drone_transfer_model.h5")
```

```
WARNING:absl:You are saving your model as an HDF5 file via `model.save()` or `keras.saving.save_model(model)`. This file format
```

```
!ls "/content/drive/MyDrive/bird_drone_project/classification_dataset/train-20251113T160913Z-1-001/train"
```

```
bird  drone
```

```
import matplotlib.pyplot as plt
import matplotlib.image as mpimg
import os

bird_path = "/content/drive/MyDrive/bird_drone_project/classification_dataset/test-20251113T154837Z-1-001/test/bird"
img_name = os.listdir(bird_path)[0]
img = mpimg.imread(os.path.join(bird_path, img_name))

plt.imshow(img)
plt.title("Bird Sample")
plt.axis('off')
```

```
(np.float64(-0.5), np.float64(415.5), np.float64(415.5), np.float64(-0.5))
```

Bird Sample



```
import matplotlib.pyplot as plt
import matplotlib.image as mpimg
import os

drone_path = "/content/drive/MyDrive/bird_drone_project/classification_dataset/test-20251113T154837Z-1-001/test/drone"
img_name = os.listdir(drone_path)[0]
img = mpimg.imread(os.path.join(drone_path, img_name))

plt.imshow(img)
plt.title("Drone Sample")
plt.axis('off')
```

```
(np.float64(-0.5), np.float64(415.5), np.float64(415.5), np.float64(-0.5))
```

Drone Sample



Download from Dreamstime.com
The image was taken by Dreamstime.com.

Twitter
Vince Barone (Dreamstime.com)

```
model_t1.save("final_bird_drone_model.h5")
```

WARNING:absl:You are saving your model as an HDF5 file via `model.save()` or `keras.saving.save_model(model)`. This file format

```
!npm install -g localtunnel
```

```
"/" "/.nvm/nvm.sh" "/.nvm/nvm.sh"
added 22 packages in 3s
:
3 packages are looking for funding
: run `npm fund` for details
:
```

```
!pip install streamlit tensorflow pillow numpy
```

```
Requirement already satisfied: packaging<26,>=20 in /usr/local/lib/python3.12/dist-packages (from streamlit) (25.0)
Requirement already satisfied: pandas<3,>=1.4.0 in /usr/local/lib/python3.12/dist-packages (from streamlit) (2.2.2)
Requirement already satisfied: protobuf<7,>=3.20 in /usr/local/lib/python3.12/dist-packages (from streamlit) (5.29.5)
Requirement already satisfied: pyarrow<22,>=7.0 in /usr/local/lib/python3.12/dist-packages (from streamlit) (18.1.0)
Requirement already satisfied: requests<3,>=2.27 in /usr/local/lib/python3.12/dist-packages (from streamlit) (2.32.4)
Requirement already satisfied: tenacity<10,>=8.1.0 in /usr/local/lib/python3.12/dist-packages (from streamlit) (9.1.2)
Requirement already satisfied: tomli<2,>=0.10.1 in /usr/local/lib/python3.12/dist-packages (from streamlit) (0.10.2)
Requirement already satisfied: typing-extensions<5,>=4.4.0 in /usr/local/lib/python3.12/dist-packages (from streamlit) (4.15.0)
Requirement already satisfied: watchdog<7,>=2.1.5 in /usr/local/lib/python3.12/dist-packages (from streamlit) (6.0.0)
Requirement already satisfied: gitpython!=3.1.19,<4,>=3.0.7 in /usr/local/lib/python3.12/dist-packages (from streamlit) (3.1.4)
Collecting pydeck<1,>=0.8.0b4 (from streamlit)
  Downloading pydeck-0.9.1-py2.py3-none-any.whl.metadata (4.1 kB)
Requirement already satisfied: tornadol!=6.5.0,<7,>=6.0.3 in /usr/local/lib/python3.12/dist-packages (from streamlit) (6.5.1)
Requirement already satisfied: absl-py>=1.0.0 in /usr/local/lib/python3.12/dist-packages (from tensorflow) (1.4.0)
Requirement already satisfied: astunparse>=1.6.0 in /usr/local/lib/python3.12/dist-packages (from tensorflow) (1.6.3)
Requirement already satisfied: flatbuffers>=24.3.25 in /usr/local/lib/python3.12/dist-packages (from tensorflow) (25.9.23)
Requirement already satisfied: gast!=0.5.0,!>0.5.1,!>0.5.2,>=0.2.1 in /usr/local/lib/python3.12/dist-packages (from tensorflow)
Requirement already satisfied: google-pasta>=0.1.1 in /usr/local/lib/python3.12/dist-packages (from tensorflow) (0.2.0)
Requirement already satisfied: libclang>=13.0.0 in /usr/local/lib/python3.12/dist-packages (from tensorflow) (18.1.1)
Requirement already satisfied: opt-einsum>=2.3.2 in /usr/local/lib/python3.12/dist-packages (from tensorflow) (3.4.0)
Requirement already satisfied: setuptools in /usr/local/lib/python3.12/dist-packages (from tensorflow) (75.2.0)
Requirement already satisfied: six>=1.12.0 in /usr/local/lib/python3.12/dist-packages (from tensorflow) (1.17.0)
Requirement already satisfied: termcolor>=1.1.0 in /usr/local/lib/python3.12/dist-packages (from tensorflow) (3.2.0)
Requirement already satisfied: wrapt>=1.11.0 in /usr/local/lib/python3.12/dist-packages (from tensorflow) (2.0.1)
Requirement already satisfied: grpcio<2.0,>=1.24.3 in /usr/local/lib/python3.12/dist-packages (from tensorflow) (1.76.0)
Requirement already satisfied: tensorboard>=2.19.0 in /usr/local/lib/python3.12/dist-packages (from tensorflow) (2.19.0)
Requirement already satisfied: keras>=3.5.0 in /usr/local/lib/python3.12/dist-packages (from tensorflow) (3.10.0)
Requirement already satisfied: h5py>=3.11.0 in /usr/local/lib/python3.12/dist-packages (from tensorflow) (3.15.1)
```

```
Requirement already satisfied: python-dateutil>=2.8.2 in /usr/local/lib/python3.12/dist-packages (from pandas<3,>=1.4.0->streamlit)
Requirement already satisfied: pytz>=2020.1 in /usr/local/lib/python3.12/dist-packages (from pandas<3,>=1.4.0->streamlit) (202)
Requirement already satisfied: tzdata>=2022.7 in /usr/local/lib/python3.12/dist-packages (from pandas<3,>=1.4.0->streamlit) (202)
Requirement already satisfied: charset_normalizer<4,>=2 in /usr/local/lib/python3.12/dist-packages (from requests<3,>=2.27->streamlit)
Requirement already satisfied: idna<4,>=2.5 in /usr/local/lib/python3.12/dist-packages (from requests<3,>=2.27->streamlit) (3.2.0)
Requirement already satisfied: urllib3<3,>=1.21.1 in /usr/local/lib/python3.12/dist-packages (from requests<3,>=2.27->streamlit)
Requirement already satisfied: certifi>=2017.4.17 in /usr/local/lib/python3.12/dist-packages (from requests<3,>=2.27->streamlit)
Requirement already satisfied: markdown>=2.6.8 in /usr/local/lib/python3.12/dist-packages (from tensorflow<2.19.0,>~2.19.0->streamlit)
Requirement already satisfied: tensorflow-data-server<0.8.0,>=0.7.0 in /usr/local/lib/python3.12/dist-packages (from tensorflow<2.19.0,>~2.19.0->streamlit)
Requirement already satisfied: werkzeug>=1.0.1 in /usr/local/lib/python3.12/dist-packages (from tensorflow<2.19.0,>~2.19.0->streamlit)
Requirement already satisfied: smmap<6,>=3.0.1 in /usr/local/lib/python3.12/dist-packages (from gitdb<5,>=4.0.1->gitpython!=3.1.0->streamlit)
Requirement already satisfied: MarkupSafe>=2.0 in /usr/local/lib/python3.12/dist-packages (from jinja2->altair!=5.4.0,!5.4.1,>5.4.1)
Requirement already satisfied: attrs>=22.2.0 in /usr/local/lib/python3.12/dist-packages (from jsonschema>=3.0->altair!=5.4.0,!5.4.1,>5.4.1)
Requirement already satisfied: jsonschema-specifications>=2023.03.6 in /usr/local/lib/python3.12/dist-packages (from jsonschema>=3.0->altair!=5.4.0,>5.4.1)
Requirement already satisfied: referencing>=0.28.4 in /usr/local/lib/python3.12/dist-packages (from jsonschema>=3.0->altair!=5.4.0,>5.4.1)
Requirement already satisfied: rpds-py>=0.7.1 in /usr/local/lib/python3.12/dist-packages (from jsonschema>=3.0->altair!=5.4.0,>5.4.1)
Requirement already satisfied: markdown-it-py>=2.2.0 in /usr/local/lib/python3.12/dist-packages (from rich->keras>=3.5.0->tensorboard<2.19.0,>~2.19.0->streamlit)
Requirement already satisfied: pygments<3.0.0,>=2.13.0 in /usr/local/lib/python3.12/dist-packages (from rich->keras>=3.5.0->tensorboard<2.19.0,>~2.19.0->streamlit)
Requirement already satisfied: mdurl~0.1 in /usr/local/lib/python3.12/dist-packages (from markdown-it-py>=2.2.0->rich->keras>=3.5.0->tensorboard<2.19.0,>~2.19.0->streamlit)
Downloading streamlit-1.51.0-py3-none-any.whl (10.2 MB)
```

```
# install streamlit
!pip install streamlit pyngrok
```

```
Requirement already satisfied: streamlit in /usr/local/lib/python3.12/dist-packages (1.51.0)
Collecting pyngrok
  Downloading pyngrok-7.5.0-py3-none-any.whl.metadata (8.1 kB)
Requirement already satisfied: altair!=5.4.0,!5.4.1,<6,>=4.0 in /usr/local/lib/python3.12/dist-packages (from streamlit) (5.5.0)
Requirement already satisfied: blinker<2,>=1.5.0 in /usr/local/lib/python3.12/dist-packages (from streamlit) (1.9.0)
Requirement already satisfied: cachetools<7,>=4.0 in /usr/local/lib/python3.12/dist-packages (from streamlit) (6.2.2)
Requirement already satisfied: click<9,>=7.0 in /usr/local/lib/python3.12/dist-packages (from streamlit) (8.3.1)
Requirement already satisfied: numpy<3,>=1.23 in /usr/local/lib/python3.12/dist-packages (from streamlit) (2.0.2)
Requirement already satisfied: packaging<26,>=20 in /usr/local/lib/python3.12/dist-packages (from streamlit) (25.0)
Requirement already satisfied: pandas<3,>=1.4.0 in /usr/local/lib/python3.12/dist-packages (from streamlit) (2.2.2)
Requirement already satisfied: pillow<13,>=7.1.0 in /usr/local/lib/python3.12/dist-packages (from streamlit) (11.3.0)
Requirement already satisfied: protobuf<7,>=3.20 in /usr/local/lib/python3.12/dist-packages (from streamlit) (5.29.5)
Requirement already satisfied: pyarrow<22,>=7.0 in /usr/local/lib/python3.12/dist-packages (from streamlit) (18.1.0)
Requirement already satisfied: requests<3,>=2.27 in /usr/local/lib/python3.12/dist-packages (from streamlit) (2.32.4)
Requirement already satisfied: tenacity<10,>=8.1.0 in /usr/local/lib/python3.12/dist-packages (from streamlit) (9.1.2)
Requirement already satisfied: toml<2,>=0.10.1 in /usr/local/lib/python3.12/dist-packages (from streamlit) (0.10.2)
Requirement already satisfied: typing-extensions<5,>=4.4.0 in /usr/local/lib/python3.12/dist-packages (from streamlit) (4.15.0)
Requirement already satisfied: watchdog<7,>=2.1.5 in /usr/local/lib/python3.12/dist-packages (from streamlit) (6.0.0)
Requirement already satisfied: gitpython!=3.1.19,<4,>=3.0.7 in /usr/local/lib/python3.12/dist-packages (from streamlit) (3.1.45)
Requirement already satisfied: pydeck<1,>=0.8.0b4 in /usr/local/lib/python3.12/dist-packages (from streamlit) (0.9.1)
Requirement already satisfied: tornado!=6.5.0,<7,>=6.0.3 in /usr/local/lib/python3.12/dist-packages (from streamlit) (6.5.1)
Requirement already satisfied: PyYAML>=5.1 in /usr/local/lib/python3.12/dist-packages (from pyngrok) (6.0.3)
Requirement already satisfied: jinja2 in /usr/local/lib/python3.12/dist-packages (from altair!=5.4.0,!5.4.1,<6,>=4.0->streamlit)
Requirement already satisfied: jsonschema>=3.0 in /usr/local/lib/python3.12/dist-packages (from altair!=5.4.0,!5.4.1,<6,>=4.0->streamlit)
Requirement already satisfied: narwhals>=1.14.2 in /usr/local/lib/python3.12/dist-packages (from altair!=5.4.0,!5.4.1,<6,>=4.0->streamlit)
Requirement already satisfied: gitdb<5,>=4.0.1 in /usr/local/lib/python3.12/dist-packages (from gitpython!=3.1.19,<4,>=3.0.7->streamlit)
Requirement already satisfied: python-dateutil>=2.8.2 in /usr/local/lib/python3.12/dist-packages (from pandas<3,>=1.4.0->streamlit)
Requirement already satisfied: pytz>=2020.1 in /usr/local/lib/python3.12/dist-packages (from pandas<3,>=1.4.0->streamlit) (2025)
Requirement already satisfied: tzdata>=2022.7 in /usr/local/lib/python3.12/dist-packages (from pandas<3,>=1.4.0->streamlit) (2025)
Requirement already satisfied: charset_normalizer<4,>=2 in /usr/local/lib/python3.12/dist-packages (from requests<3,>=2.27->streamlit)
Requirement already satisfied: idna<4,>=2.5 in /usr/local/lib/python3.12/dist-packages (from requests<3,>=2.27->streamlit) (3.11)
Requirement already satisfied: urllib3<3,>=1.21.1 in /usr/local/lib/python3.12/dist-packages (from requests<3,>=2.27->streamlit)
Requirement already satisfied: certifi>=2017.4.17 in /usr/local/lib/python3.12/dist-packages (from requests<3,>=2.27->streamlit)
Requirement already satisfied: smmap<6,>=3.0.1 in /usr/local/lib/python3.12/dist-packages (from gitdb<5,>=4.0.1->gitpython!=3.1.0->streamlit)
Requirement already satisfied: MarkupSafe>=2.0 in /usr/local/lib/python3.12/dist-packages (from jinja2->altair!=5.4.0,!5.4.1,<6,>=4.0->streamlit)
Requirement already satisfied: attrs>=22.2.0 in /usr/local/lib/python3.12/dist-packages (from jsonschema>=3.0->altair!=5.4.0,!5.4.1,>5.4.1)
Requirement already satisfied: jsonschema-specifications>=2023.03.6 in /usr/local/lib/python3.12/dist-packages (from jsonschema>=3.0->altair!=5.4.0,>5.4.1)
Requirement already satisfied: referencing>=0.28.4 in /usr/local/lib/python3.12/dist-packages (from jsonschema>=3.0->altair!=5.4.0,>5.4.1)
Requirement already satisfied: rpds-py>=0.7.1 in /usr/local/lib/python3.12/dist-packages (from jsonschema>=3.0->altair!=5.4.0,>5.4.1)
Requirement already satisfied: six>=1.5 in /usr/local/lib/python3.12/dist-packages (from python-dateutil>=2.8.2->pandas<3,>=1.4.0)
Downloading pyngrok-7.5.0-py3-none-any.whl (24 kB)
Installing collected packages: pyngrok
Successfully installed pyngrok-7.5.0
```

```
!pip install ultralytics
```

```
Requirement already satisfied: ultralytics in /usr/local/lib/python3.12/dist-packages (8.3.232)
Requirement already satisfied: numpy>=1.23.0 in /usr/local/lib/python3.12/dist-packages (from ultralytics) (2.0.2)
Requirement already satisfied: matplotlib>=3.3.0 in /usr/local/lib/python3.12/dist-packages (from ultralytics) (3.10.0)
Requirement already satisfied: opencv-python>=4.6.0 in /usr/local/lib/python3.12/dist-packages (from ultralytics) (4.12.0.88)
Requirement already satisfied: pillow>7.1.2 in /usr/local/lib/python3.12/dist-packages (from ultralytics) (11.3.0)
Requirement already satisfied: pyyaml>=5.3.1 in /usr/local/lib/python3.12/dist-packages (from ultralytics) (6.0.3)
Requirement already satisfied: requests>=2.23.0 in /usr/local/lib/python3.12/dist-packages (from ultralytics) (2.32.4)
Requirement already satisfied: scipy>=1.4.1 in /usr/local/lib/python3.12/dist-packages (from ultralytics) (1.16.3)
Requirement already satisfied: torch>=1.8.0 in /usr/local/lib/python3.12/dist-packages (from ultralytics) (2.9.0+cu126)
Requirement already satisfied: torchvision>=0.9.0 in /usr/local/lib/python3.12/dist-packages (from ultralytics) (0.24.0+cu126)
```

```
Requirement already satisfied: psutil>=5.8.0 in /usr/local/lib/python3.12/dist-packages (from ultralytics) (5.9.5)
Requirement already satisfied: polars>=0.20.0 in /usr/local/lib/python3.12/dist-packages (from ultralytics) (1.31.0)
Requirement already satisfied: ultralytics-thop>=2.0.18 in /usr/local/lib/python3.12/dist-packages (from ultralytics) (2.0.18)
Requirement already satisfied: contourpy>=1.0.1 in /usr/local/lib/python3.12/dist-packages (from matplotlib>=3.3.0->ultralytics)
Requirement already satisfied: cycler>=0.10 in /usr/local/lib/python3.12/dist-packages (from matplotlib>=3.3.0->ultralytics) (0.
Requirement already satisfied: fonttools>=4.22.0 in /usr/local/lib/python3.12/dist-packages (from matplotlib>=3.3.0->ultralytics)
Requirement already satisfied: kiwisolver>=1.3.1 in /usr/local/lib/python3.12/dist-packages (from matplotlib>=3.3.0->ultralytics)
Requirement already satisfied: packaging>=20.0 in /usr/local/lib/python3.12/dist-packages (from matplotlib>=3.3.0->ultralytics)
Requirement already satisfied: pyparsing>=2.3.1 in /usr/local/lib/python3.12/dist-packages (from matplotlib>=3.3.0->ultralytics)
Requirement already satisfied: python-dateutil>=2.7 in /usr/local/lib/python3.12/dist-packages (from matplotlib>=3.3.0->ultralyt
Requirement already satisfied: charset_normalizer<4,>=2 in /usr/local/lib/python3.12/dist-packages (from requests>=2.23.0->ultra
Requirement already satisfied: idna<4,>=2.5 in /usr/local/lib/python3.12/dist-packages (from requests>=2.23.0->ultralytics) (3.1
Requirement already satisfied: urllib3<3,>=1.21.1 in /usr/local/lib/python3.12/dist-packages (from requests>=2.23.0->ultralytics)
Requirement already satisfied: certifi>=2017.4.17 in /usr/local/lib/python3.12/dist-packages (from requests>=2.23.0->ultralytics)
Requirement already satisfied: filelock in /usr/local/lib/python3.12/dist-packages (from torch>=1.8.0->ultralytics) (3.20.0)
Requirement already satisfied: typing-extensions>=4.10.0 in /usr/local/lib/python3.12/dist-packages (from torch>=1.8.0->ultralyt
Requirement already satisfied: setuptools in /usr/local/lib/python3.12/dist-packages (from torch>=1.8.0->ultralytics) (75.2.0)
Requirement already satisfied: sympy>=1.13.3 in /usr/local/lib/python3.12/dist-packages (from torch>=1.8.0->ultralytics) (1.14.0)
Requirement already satisfied: networkx>=2.5.1 in /usr/local/lib/python3.12/dist-packages (from torch>=1.8.0->ultralytics) (3.5)
Requirement already satisfied: jinja2 in /usr/local/lib/python3.12/dist-packages (from torch>=1.8.0->ultralytics) (3.1.6)
Requirement already satisfied: fsspec>=0.8.5 in /usr/local/lib/python3.12/dist-packages (from torch>=1.8.0->ultralytics) (2025.3
Requirement already satisfied: nvidia-cuda-nvrtc-cu12==12.6.77 in /usr/local/lib/python3.12/dist-packages (from torch>=1.8.0->ul
Requirement already satisfied: nvidia-cuda-runtime-cu12==12.6.77 in /usr/local/lib/python3.12/dist-packages (from torch>=1.8.0->
Requirement already satisfied: nvidia-cuda-cupti-cu12==12.6.80 in /usr/local/lib/python3.12/dist-packages (from torch>=1.8.0->ul
Requirement already satisfied: nvidia-cudnn-cu12==9.10.2.21 in /usr/local/lib/python3.12/dist-packages (from torch>=1.8.0->ultra
Requirement already satisfied: nvidia-cublas-cu12==12.6.4.1 in /usr/local/lib/python3.12/dist-packages (from torch>=1.8.0->ultra
Requirement already satisfied: nvidia-cufft-cu12==11.3.0.4 in /usr/local/lib/python3.12/dist-packages (from torch>=1.8.0->ultral
Requirement already satisfied: nvidia-curand-cu12==10.3.7.77 in /usr/local/lib/python3.12/dist-packages (from torch>=1.8.0->ultr
Requirement already satisfied: nvidia-cusolver-cu12==11.7.1.2 in /usr/local/lib/python3.12/dist-packages (from torch>=1.8.0->ult
Requirement already satisfied: nvidia-cusparse-cu12==12.5.4.2 in /usr/local/lib/python3.12/dist-packages (from torch>=1.8.0->ult
Requirement already satisfied: nvidia-cusparseLt-cu12==0.7.1 in /usr/local/lib/python3.12/dist-packages (from torch>=1.8.0->ultr
Requirement already satisfied: nvidia-nccl-cu12==2.27.5 in /usr/local/lib/python3.12/dist-packages (from torch>=1.8.0->ultralyti
Requirement already satisfied: nvidia-nvshmem-cu12==3.3.20 in /usr/local/lib/python3.12/dist-packages (from torch>=1.8.0->ultral
Requirement already satisfied: nvidia-nvtx-cu12==12.6.77 in /usr/local/lib/python3.12/dist-packages (from torch>=1.8.0->ultralyt
Requirement already satisfied: nvidia-nvjitlink-cu12==12.6.85 in /usr/local/lib/python3.12/dist-packages (from torch>=1.8.0->ult
Requirement already satisfied: nvidia-cufile-cu12==1.11.1.6 in /usr/local/lib/python3.12/dist-packages (from torch>=1.8.0->ultra
Requirement already satisfied: triton==3.5.0 in /usr/local/lib/python3.12/dist-packages (from torch>=1.8.0->ultralytics) (3.5.0)
Requirement already satisfied: six>=1.5 in /usr/local/lib/python3.12/dist-packages (from python-dateutil>=2.7->matplotlib>=3.3.0
Requirement already satisfied: mpmath<1.4,>=1.1.0 in /usr/local/lib/python3.12/dist-packages (from sympy>=1.13.3->torch>=1.8.0->
Requirement already satisfied: MarkupSafe>=2.0 in /usr/local/lib/python3.12/dist-packages (from jinja2->torch>=1.8.0->ultralytic
```

```
# Token Add
!ngrok config add-authtoken "34pBZArucIzwiqZA2y1JZjVBDBj_2o3vCZUEdbHzeuW5h9nfi"
```

Authtoken saved to configuration file: /root/.config/ngrok/ngrok.yml

```
%>writefile app_advanced.py
import streamlit as st
from PIL import Image
import numpy as np
import tensorflow as tf

st.set_page_config(page_title="Bird & Drone Detector", layout="wide")
st.title("Bird & Drone Classification")

# Load Keras model
MODEL_PATH = "/content/bird_drone_transfer_model.h5"

try:
    model = tf.keras.models.load_model(MODEL_PATH)
    st.success("Model Loaded Successfully!")
except Exception as e:
    st.error(f"Model Load Error: {e}")

# Upload image
uploaded_file = st.file_uploader("Upload an Image", type=["jpg", "png", "jpeg"])

def preprocess(img):
    img = img.resize((224, 224))          # same size as training
    img = np.array(img) / 255.0            # normalize
    img = np.expand_dims(img, axis=0)      # batch dimension
    return img

if uploaded_file:
    image = Image.open(uploaded_file)
    st.image(image, caption="Uploaded Image", use_container_width=True)

if st.button("Run Detection"):
```

```
img_prep = preprocess(image)

preds = model.predict(img_prep)[0]

bird_prob = preds[0]
drone_prob = preds[1]

label = "Bird" if bird_prob > drone_prob else "Drone"
accuracy = max(bird_prob, drone_prob) * 100

# COUNT -> 1 image = 1 object
bird_count = 1 if label == "Bird" else 0
drone_count = 1 if label == "Drone" else 0

st.subheader("📊 Detection Summary")
st.write(f"**Prediction:** {label}")
st.write(f"**Bird Count:** {bird_count}")
st.write(f"**Drone Count:** {drone_count}")
st.write(f"**Accuracy:** {accuracy:.2f}%")
```

Overwriting app_advanced.py

```
!nohup streamlit run app.py --server.port 8501 &
ngrok.connect(8501)
```

```
nohup: appending output to 'nohup.out'
<NgrokTunnel: "https://crystallizable-audie-compressed.ngrok-free.dev" -> "http://localhost:8501">
```