Assignment-2

*Convolution *

Downloading the data

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

Copying images to training, validation, and test directories

```
import os
import shutil
import pathlib

# Define original folders separately
original_train_dir = pathlib.Path("/content/drive/MyDrive/AML/cats_vs_dogs_small/train")
original_val_dir = pathlib.Path("/content/drive/MyDrive/AML/cats_vs_dogs_small/validation")
original_test_dir = pathlib.Path("/content/drive/MyDrive/AML/cats_vs_dogs_small/test")

# Define destination base directory
new_base_dir = pathlib.Path("/content/drive/MyDrive/AML/cats_vs_dogs_small 2/small_dataset_balanced")

def make_subset_from_folder(subset_name, original_folder, start_index, end_index):

    print(f"\nCreating '{subset_name}' from {original_folder} indices {start_index} to {end_index}")

    for category in ["cats", "dogs"]:
        src_dir = original_folder / category
        dest_dir = new_base_dir / subset_name / category

        os.makedirs(dest_dir, exist_ok=True)

        files = sorted(os.listdir(src_dir))

        # Adjust end_index if it's too big
        if end_index > len(files):
            print(f" WARNING: end_index {end_index} exceeds available files ({len(files)}). Adjusting.")
            end_index = len(files)

        subset_files = files[start_index:end_index]
        print(f"Copying {len(subset_files)} '{category}' images to '{dest_dir}'...")

        for fname in subset_files:
            src_file = src_dir / fname
            dst_file = dest_dir / fname
            shutil.copyfile(src_file, dst_file)

    print(f" {subset_name} created from {original_folder}.")

def main():


   # 1000 images from original train folder for training
    make_subset_from_folder("train", original_train_dir, 0, 500)

    # 250 images from original validation folder for validation
    make_subset_from_folder("validation", original_val_dir, 0, 250)

    # 250 images from original test folder for testing
    make_subset_from_folder("test", original_test_dir, 0, 250)

if __name__ == "__main__":
    main()
```

```
Creating 'train' from /content/drive/MyDrive/AML/cats_vs_dogs_small/train indices 0 to 500
Copying 500 'cats' images to '/content/drive/MyDrive/AML/cats_vs_dogs_small 2/small_dataset_balanced/train/cats'...
Copying 500 'dogs' images to '/content/drive/MyDrive/AML/cats_vs_dogs_small 2/small_dataset_balanced/train/dogs'...
✅ train created from /content/drive/MyDrive/AML/cats_vs_dogs_small/train.

Creating 'validation' from /content/drive/MyDrive/AML/cats_vs_dogs_small/validation indices 0 to 250
Copying 250 'cats' images to '/content/drive/MyDrive/AML/cats_vs_dogs_small 2/small_dataset_balanced/validation/cats'...
Copying 250 'dogs' images to '/content/drive/MyDrive/AML/cats_vs_dogs_small 2/small_dataset_balanced/validation/dogs'...
```

```
✅ validation created from /content/drive/MyDrive/AML/cats_vs_dogs_small/validation.

Creating 'test' from /content/drive/MyDrive/AML/cats_vs_dogs_small/test indices 0 to 250
Copying 250 'cats' images to '/content/drive/MyDrive/AML/cats_vs_dogs_small 2/small_dataset_balanced/test/cats'...
Copying 250 'dogs' images to '/content/drive/MyDrive/AML/cats_vs_dogs_small 2/small_dataset_balanced/test/dogs'...
✅ test created from /content/drive/MyDrive/AML/cats_vs_dogs_small/test.
```

```
make_subset_from_folder("train", original_train_dir, 0, 500)
make_subset_from_folder("validation", original_val_dir, 0, 250)
make_subset_from_folder("test", original_test_dir, 0, 250)
```

```
from tensorflow.keras.utils import image_dataset_from_directory

train_dataset = image_dataset_from_directory(
    new_base_dir / "train",
    image_size=(180, 180),
    batch_size=32
)

validation_dataset = image_dataset_from_directory(
    new_base_dir / "validation",
    image_size=(180, 180),
    batch_size=32
)

test_dataset = image_dataset_from_directory(
    new_base_dir / "test",
    image_size=(180, 180),
    batch_size=32
)
```

Training the convent network from scratch

Model 1:Training sample of 1000, a validation sample of 500, and a test sample of 500

```
from tensorflow import keras
from tensorflow.keras import layers
```

Instantiating a small convnet for dogs vs. cats classification

```
inputs = keras.Input(shape=(180, 180, 3))
x = layers.Rescaling(1./255)(inputs)
x = layers.Conv2D(filters=32, kernel_size=3, activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)
x = layers.Conv2D(filters=64, kernel_size=3, activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)
x = layers.Conv2D(filters=128, kernel_size=3, activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)
x = layers.Conv2D(filters=256, kernel_size=3, activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)
x = layers.Conv2D(filters=256, kernel_size=3, activation="relu")(x)
x = layers.Flatten()(x)
outputs = layers.Dense(1, activation="sigmoid")(x)
model = keras.Model(inputs=inputs, outputs=outputs)
```

```
model.summary()
```

Configuring the model for training

```
model.compile(loss="binary_crossentropy",
              optimizer="rmsprop",
              metrics=["accuracy"])
```

Data preprocessing

```
from tensorflow.keras.utils import image_dataset_from_directory

# Base directory for the subsets
```

```
subset_dir = pathlib.Path("/content/drive/MyDrive/AML/cats_vs_dogs_small 2/small_dataset_balanced")

# Load datasets
train_dataset = image_dataset_from_directory(
    subset_dir / "train",
    image_size=(180, 180),
    batch_size=32
)

validation_dataset = image_dataset_from_directory(
    subset_dir / "validation",
    image_size=(180, 180),
    batch_size=32
)

test_dataset = image_dataset_from_directory(
    subset_dir / "test",
    image_size=(180, 180),
    batch_size=32
)


import numpy as np
import tensorflow as tf
random_numbers = np.random.normal(size=(1000, 16))
dataset = tf.data.Dataset.from_tensor_slices(random_numbers)


for i, element in enumerate(dataset):
    print(element.shape)
    if i >= 2:
        break


batched_dataset = dataset.batch(32)
for i, element in enumerate(batched_dataset):
    print(element.shape)
    if i >= 2:
        break


reshaped_dataset = dataset.map(lambda x: tf.reshape(x, (4, 4)))
for i, element in enumerate(reshaped_dataset):
    print(element.shape)
    if i >= 2:
        break
```

Displaying the shapes of the data and labels yielded by the Dataset

```
for data_batch, labels_batch in train_dataset:
    print("data batch shape:", data_batch.shape)
    print("labels batch shape:", labels_batch.shape)
    break
```

Fitting the model using a Dataset

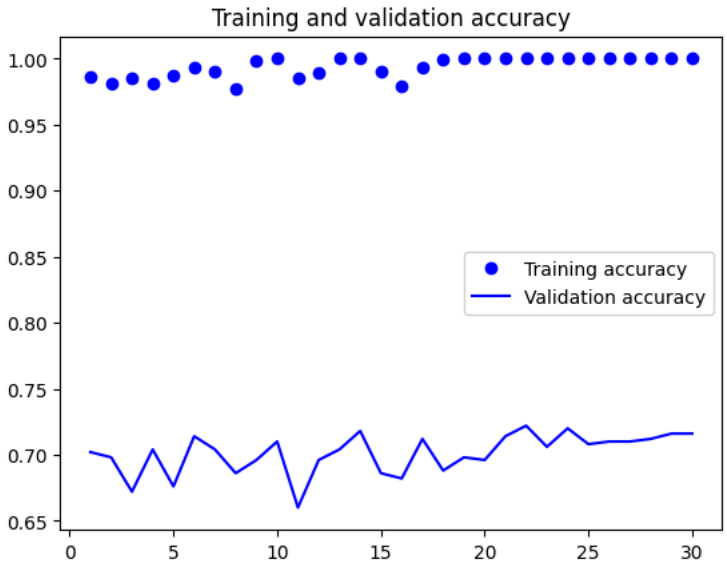
```
callbacks = [
    keras.callbacks.ModelCheckpoint(
        filepath="convnet_from_scratch.keras",
        save_best_only=True,
        monitor="val_loss")
]
history = model.fit(
    train_dataset,
    epochs=30,
    validation_data=validation_dataset,
    callbacks=callbacks)
```

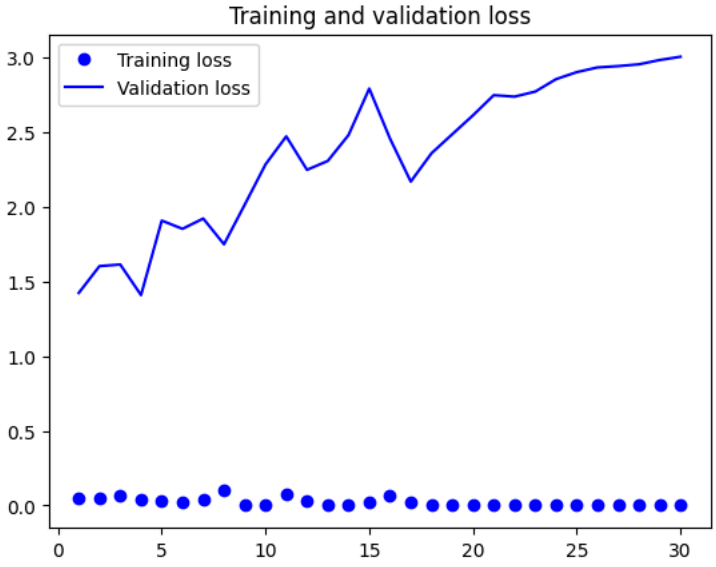
```
Epoch 2/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 181ms/step - accuracy: 0.9784 - loss: 0.0562 - val_accuracy: 0.6980 - val_loss: 1.6040
Epoch 3/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 5s 161ms/step - accuracy: 0.9907 - loss: 0.0445 - val_accuracy: 0.6720 - val_loss: 1.6145
Epoch 4/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 12s 224ms/step - accuracy: 0.9748 - loss: 0.0598 - val_accuracy: 0.7040 - val_loss: 1.4100
Epoch 5/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 9s 183ms/step - accuracy: 0.9899 - loss: 0.0313 - val_accuracy: 0.6760 - val_loss: 1.9088
Epoch 6/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 9s 153ms/step - accuracy: 0.9866 - loss: 0.0358 - val_accuracy: 0.7140 - val_loss: 1.8536
Epoch 7/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 190ms/step - accuracy: 0.9952 - loss: 0.0194 - val_accuracy: 0.7040 - val_loss: 1.9225
```

```
Epoch 9/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 10s 185ms/step - accuracy: 0.9979 - loss: 0.0115 - val_accuracy: 0.6960 - val_loss: 2.0160
Epoch 10/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 7s 221ms/step - accuracy: 1.0000 - loss: 0.0010 - val_accuracy: 0.7100 - val_loss: 2.2852
Epoch 11/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 5s 150ms/step - accuracy: 0.9975 - loss: 0.0142 - val_accuracy: 0.6600 - val_loss: 2.4729
Epoch 12/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 188ms/step - accuracy: 0.9816 - loss: 0.0593 - val_accuracy: 0.6960 - val_loss: 2.2489
Epoch 13/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 9s 153ms/step - accuracy: 1.0000 - loss: 7.7117e-04 - val_accuracy: 0.7040 - val_loss: 2.3084
Epoch 14/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 193ms/step - accuracy: 1.0000 - loss: 1.6007e-04 - val_accuracy: 0.7180 - val_loss: 2.4816
Epoch 15/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 5s 156ms/step - accuracy: 0.9983 - loss: 0.0046 - val_accuracy: 0.6860 - val_loss: 2.7933
Epoch 16/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 192ms/step - accuracy: 0.9890 - loss: 0.0421 - val_accuracy: 0.6820 - val_loss: 2.4579
Epoch 17/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 9s 158ms/step - accuracy: 0.9849 - loss: 0.0349 - val_accuracy: 0.7120 - val_loss: 2.1702
Epoch 18/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 191ms/step - accuracy: 0.9987 - loss: 0.0037 - val_accuracy: 0.6880 - val_loss: 2.3599
Epoch 19/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 187ms/step - accuracy: 1.0000 - loss: 1.8574e-04 - val_accuracy: 0.6980 - val_loss: 2.4874
Epoch 20/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 7s 210ms/step - accuracy: 1.0000 - loss: 5.3500e-05 - val_accuracy: 0.6960 - val_loss: 2.6143
Epoch 21/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 5s 156ms/step - accuracy: 1.0000 - loss: 3.3315e-05 - val_accuracy: 0.7140 - val_loss: 2.7491
Epoch 22/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 192ms/step - accuracy: 1.0000 - loss: 2.2664e-05 - val_accuracy: 0.7220 - val_loss: 2.7391
Epoch 23/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 9s 163ms/step - accuracy: 1.0000 - loss: 9.9674e-06 - val_accuracy: 0.7060 - val_loss: 2.7730
Epoch 24/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 10s 164ms/step - accuracy: 1.0000 - loss: 7.1740e-06 - val_accuracy: 0.7200 - val_loss: 2.856
Epoch 25/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 11s 194ms/step - accuracy: 1.0000 - loss: 6.3969e-06 - val_accuracy: 0.7080 - val_loss: 2.903
Epoch 26/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 190ms/step - accuracy: 1.0000 - loss: 4.0050e-06 - val_accuracy: 0.7100 - val_loss: 2.9350
Epoch 27/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 5s 169ms/step - accuracy: 1.0000 - loss: 4.5808e-06 - val_accuracy: 0.7100 - val_loss: 2.9438
Epoch 28/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 5s 159ms/step - accuracy: 1.0000 - loss: 3.3349e-06 - val_accuracy: 0.7120 - val_loss: 2.9558
Epoch 29/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 189ms/step - accuracy: 1.0000 - loss: 3.5103e-06 - val_accuracy: 0.7160 - val_loss: 2.9847
Epoch 30/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 10s 186ms/step - accuracy: 1.0000 - loss: 3.1251e-06 - val_accuracy: 0.7160 - val_loss: 3.006
```

Displaying curves of loss and accuracy during training

```
import matplotlib.pyplot as plt
accuracy = history.history["accuracy"]
val_accuracy = history.history["val_accuracy"]
loss = history.history["loss"]
val_loss = history.history["val_loss"]
epochs = range(1, len(accuracy) + 1)
plt.plot(epochs, accuracy, "bo", label="Training accuracy")
plt.plot(epochs, val_accuracy, "b", label="Validation accuracy")
plt.title("Training and validation accuracy")
plt.legend()
plt.figure()
plt.plot(epochs, loss, "bo", label="Training loss")
plt.plot(epochs, val_loss, "b", label="Validation loss")
plt.title("Training and validation loss")
plt.legend()
plt.show()
```





Evaluating the model on the test set

```
test_model = keras.models.load_model("convnet_from_scratch.keras")
test_loss, test_acc = test_model.evaluate(test_dataset)
print(f"Test accuracy: {test_acc:.3f}")
```

```
16/16 ━━━━━━━━━━━━━━━━━━━━ 2s 98ms/step - accuracy: 0.6954 - loss: 1.3531
Test accuracy: 0.680
```

Since the validation and the tes accuracy of the model is very low that is 68%

To improve performance in developing a network that we trained from scratch, we will train our model on following techniques.

Model 1a: Using Data Augmentation

```
from tensorflow import keras
from tensorflow.keras import layers
data_augmentation = keras.Sequential(
    [
        layers.RandomFlip("horizontal"),
        layers.RandomRotation(0.1),
        layers.RandomZoom(0.2),
    ]
)
```

```
inputs = keras.Input(shape=(180, 180, 3))
x = data_augmentation(inputs)
x = layers.Rescaling(1./255)(x)
x = layers.Conv2D(filters=32, kernel_size=3, activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)
```

```
x = layers.Conv2D(filters=64, kernel_size=3, activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)
x = layers.Conv2D(filters=128, kernel_size=3, activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)
x = layers.Conv2D(filters=256, kernel_size=3, activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)
x = layers.Conv2D(filters=256, kernel_size=3, activation="relu")(x)
x = layers.Flatten()(x)
outputs = layers.Dense(1, activation="sigmoid")(x)
model = keras.Model(inputs=inputs, outputs=outputs)

model.compile(loss="binary_crossentropy",
              optimizer="rmsprop",
              metrics=["accuracy"])


callbacks = [
    keras.callbacks.ModelCheckpoint(
        filepath="convnet_from_scratch_with_augmentation.keras",
        save_best_only=True,
        monitor="val_loss")
]
history = model.fit(
    train_dataset,
    epochs=30,
    validation_data=validation_dataset,
     callbacks=callbacks)
```

```
Epoch 2/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 5s 161ms/step - accuracy: 0.5202 - loss: 0.6932 - val_accuracy: 0.5000 - val_loss: 0.8568
Epoch 3/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 183ms/step - accuracy: 0.4901 - loss: 0.7313 - val_accuracy: 0.5000 - val_loss: 0.6929
Epoch 4/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 5s 169ms/step - accuracy: 0.4770 - loss: 0.6940 - val_accuracy: 0.5000 - val_loss: 0.7123
Epoch 5/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 5s 153ms/step - accuracy: 0.5161 - loss: 0.6943 - val_accuracy: 0.5340 - val_loss: 0.6901
Epoch 6/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 7s 227ms/step - accuracy: 0.5673 - loss: 0.6866 - val_accuracy: 0.5560 - val_loss: 0.6743
Epoch 7/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 183ms/step - accuracy: 0.6490 - loss: 0.6765 - val_accuracy: 0.5560 - val_loss: 0.7657
Epoch 8/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 9s 154ms/step - accuracy: 0.5770 - loss: 0.6862 - val_accuracy: 0.6180 - val_loss: 0.6675
Epoch 9/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 7s 209ms/step - accuracy: 0.6222 - loss: 0.6679 - val_accuracy: 0.6540 - val_loss: 0.6293
Epoch 10/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 185ms/step - accuracy: 0.6550 - loss: 0.6397 - val_accuracy: 0.6440 - val_loss: 0.6309
Epoch 11/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 5s 162ms/step - accuracy: 0.6436 - loss: 0.6462 - val_accuracy: 0.5980 - val_loss: 0.6575
Epoch 12/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 7s 208ms/step - accuracy: 0.6542 - loss: 0.6226 - val_accuracy: 0.6820 - val_loss: 0.5952
Epoch 13/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 182ms/step - accuracy: 0.6781 - loss: 0.5927 - val_accuracy: 0.5760 - val_loss: 0.9135
Epoch 14/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 9s 150ms/step - accuracy: 0.6993 - loss: 0.5801 - val_accuracy: 0.6520 - val_loss: 0.6098
Epoch 15/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 198ms/step - accuracy: 0.7040 - loss: 0.5573 - val_accuracy: 0.7000 - val_loss: 0.5678
Epoch 16/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 9s 151ms/step - accuracy: 0.7013 - loss: 0.5459 - val_accuracy: 0.5780 - val_loss: 0.7547
Epoch 17/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 7s 217ms/step - accuracy: 0.7116 - loss: 0.5781 - val_accuracy: 0.6120 - val_loss: 0.6559
Epoch 18/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 5s 152ms/step - accuracy: 0.7029 - loss: 0.5773 - val_accuracy: 0.6960 - val_loss: 0.5807
Epoch 19/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 190ms/step - accuracy: 0.7262 - loss: 0.5331 - val_accuracy: 0.7100 - val_loss: 0.5447
Epoch 20/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 9s 148ms/step - accuracy: 0.7343 - loss: 0.5324 - val_accuracy: 0.6080 - val_loss: 0.6452
Epoch 21/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 7s 221ms/step - accuracy: 0.7282 - loss: 0.5447 - val_accuracy: 0.6540 - val_loss: 0.6239
Epoch 22/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 8s 164ms/step - accuracy: 0.7288 - loss: 0.5270 - val_accuracy: 0.6760 - val_loss: 0.6904
Epoch 23/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 10s 144ms/step - accuracy: 0.7667 - loss: 0.5307 - val_accuracy: 0.6960 - val_loss: 0.6706
Epoch 24/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 7s 220ms/step - accuracy: 0.7295 - loss: 0.5244 - val_accuracy: 0.7500 - val_loss: 0.5293
Epoch 25/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 8s 155ms/step - accuracy: 0.7840 - loss: 0.4791 - val_accuracy: 0.6800 - val_loss: 0.6528
Epoch 26/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 174ms/step - accuracy: 0.7563 - loss: 0.5179 - val_accuracy: 0.7140 - val_loss: 0.5965
Epoch 27/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 5s 146ms/step - accuracy: 0.7792 - loss: 0.4753 - val_accuracy: 0.7460 - val_loss: 0.5566
Epoch 28/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 195ms/step - accuracy: 0.7752 - loss: 0.4720 - val_accuracy: 0.7320 - val_loss: 0.5612
Epoch 29/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 5s 145ms/step - accuracy: 0.7693 - loss: 0.4993 - val_accuracy: 0.7160 - val_loss: 0.5738
Epoch 30/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 5s 156ms/step - accuracy: 0.7976 - loss: 0.4526 - val_accuracy: 0.7160 - val_loss: 0.5901
```

```
test_model = keras.models.load_model(
    "convnet_from_scratch_with_augmentation.keras")
test_loss, test_acc = test_model.evaluate(test_dataset)
print(f"Test accuracy: {test_acc:.3f}")
```

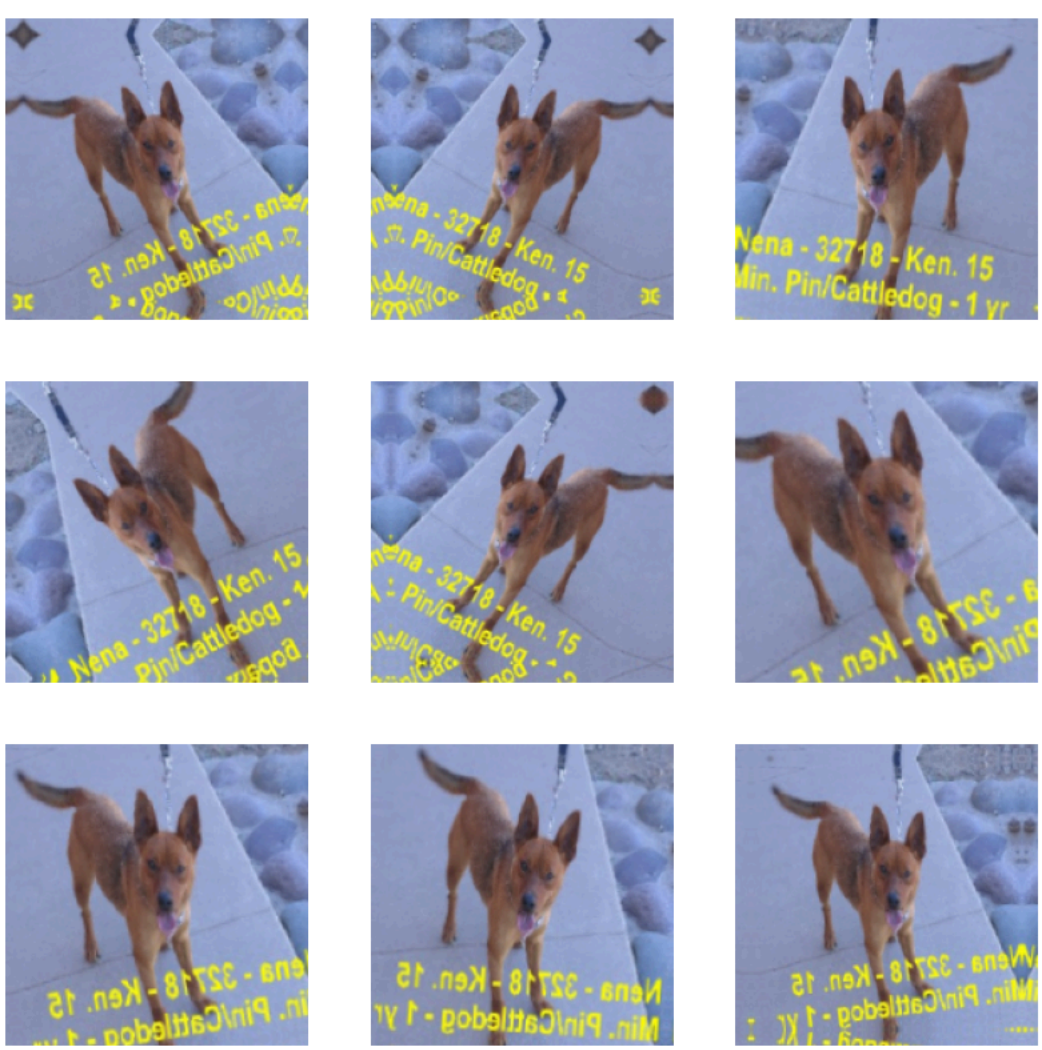
```
16/16 ━━━━━━━━━━━━━━━━━━━━ 2s 92ms/step - accuracy: 0.7073 - loss: 0.5761
Test accuracy: 0.698
```

Defining a data augmentation stage to add to an image model

```
data_augmentation = keras.Sequential(
    [
        layers.RandomFlip("horizontal"),
        layers.RandomRotation(0.1),
        layers.RandomZoom(0.2),
    ]
)
```

Displaying some randomly augmented training images

```
plt.figure(figsize=(10, 10))
for images, _ in train_dataset.take(1):
    for i in range(9):
        augmented_images = data_augmentation(images)
        ax = plt.subplot(3, 3, i + 1)
        plt.imshow(augmented_images[0].numpy().astype("uint8"))
        plt.axis("off")
```



Model 1b: Using Dropout Method

```
inputs = keras.Input(shape=(180, 180, 3))
x = layers.Rescaling(1./255)(inputs)
x = layers.Conv2D(filters=32, kernel_size=3, activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)
x = layers.Conv2D(filters=64, kernel_size=3, activation="relu")(x)
```

```
x = layers.MaxPooling2D(pool_size=2)(x)
x = layers.Conv2D(filters=128, kernel_size=3, activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)
x = layers.Conv2D(filters=256, kernel_size=3, activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)
x = layers.Conv2D(filters=256, kernel_size=3, activation="relu")(x)
x = layers.Flatten()(x)
x = layers.Dropout(0.5)(x)
outputs = layers.Dense(1, activation="sigmoid")(x)
model = keras.Model(inputs=inputs, outputs=outputs)

model.compile(loss="binary_crossentropy",
              optimizer="rmsprop",
              metrics=["accuracy"])


callbacks = [
    keras.callbacks.ModelCheckpoint(
        filepath="convnet_from_scratch_with_dropout.keras",
        save_best_only=True,
        monitor="val_loss")
]
history = model.fit(
    train_dataset,
    epochs=30,
    validation_data=validation_dataset,
    callbacks=callbacks)
```

```
Epoch 2/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 16s 179ms/step - accuracy: 0.5061 - loss: 0.6937 - val_accuracy: 0.5000 - val_loss: 0.6934
Epoch 3/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 179ms/step - accuracy: 0.5237 - loss: 0.6947 - val_accuracy: 0.5000 - val_loss: 0.6923
Epoch 4/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 10s 186ms/step - accuracy: 0.5815 - loss: 0.7001 - val_accuracy: 0.5000 - val_loss: 0.6910
Epoch 5/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 177ms/step - accuracy: 0.5315 - loss: 0.6916 - val_accuracy: 0.5080 - val_loss: 0.6986
Epoch 6/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 180ms/step - accuracy: 0.5505 - loss: 0.6859 - val_accuracy: 0.6500 - val_loss: 0.6789
Epoch 7/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 9s 142ms/step - accuracy: 0.6091 - loss: 0.6677 - val_accuracy: 0.5320 - val_loss: 0.9232
Epoch 8/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 180ms/step - accuracy: 0.5876 - loss: 0.6922 - val_accuracy: 0.6400 - val_loss: 0.6296
Epoch 9/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 5s 141ms/step - accuracy: 0.6460 - loss: 0.6246 - val_accuracy: 0.5720 - val_loss: 0.7152
Epoch 10/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 5s 155ms/step - accuracy: 0.6590 - loss: 0.6233 - val_accuracy: 0.5500 - val_loss: 0.7159
Epoch 11/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 7s 208ms/step - accuracy: 0.6745 - loss: 0.6024 - val_accuracy: 0.6020 - val_loss: 0.7066
Epoch 12/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 5s 152ms/step - accuracy: 0.6813 - loss: 0.5918 - val_accuracy: 0.6560 - val_loss: 0.6261
Epoch 13/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 7s 218ms/step - accuracy: 0.7195 - loss: 0.5382 - val_accuracy: 0.6220 - val_loss: 0.8872
Epoch 14/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 5s 147ms/step - accuracy: 0.7211 - loss: 0.5528 - val_accuracy: 0.6480 - val_loss: 0.6442
Epoch 15/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 191ms/step - accuracy: 0.7541 - loss: 0.5042 - val_accuracy: 0.6680 - val_loss: 0.6225
Epoch 16/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 182ms/step - accuracy: 0.7734 - loss: 0.4610 - val_accuracy: 0.6860 - val_loss: 0.6184
Epoch 17/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 10s 172ms/step - accuracy: 0.7998 - loss: 0.4282 - val_accuracy: 0.6540 - val_loss: 0.6433
Epoch 18/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 5s 144ms/step - accuracy: 0.8029 - loss: 0.4348 - val_accuracy: 0.5560 - val_loss: 2.2641
Epoch 19/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 7s 195ms/step - accuracy: 0.7926 - loss: 0.5551 - val_accuracy: 0.6940 - val_loss: 0.6944
Epoch 20/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 5s 148ms/step - accuracy: 0.8343 - loss: 0.3702 - val_accuracy: 0.6320 - val_loss: 0.7278
Epoch 21/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 181ms/step - accuracy: 0.8573 - loss: 0.3300 - val_accuracy: 0.6800 - val_loss: 0.6121
Epoch 22/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 5s 152ms/step - accuracy: 0.9148 - loss: 0.2353 - val_accuracy: 0.7100 - val_loss: 0.7081
Epoch 23/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 5s 143ms/step - accuracy: 0.8963 - loss: 0.2329 - val_accuracy: 0.7100 - val_loss: 0.6670
Epoch 24/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 7s 205ms/step - accuracy: 0.9212 - loss: 0.2164 - val_accuracy: 0.7080 - val_loss: 0.9501
Epoch 25/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 5s 141ms/step - accuracy: 0.9127 - loss: 0.2064 - val_accuracy: 0.7180 - val_loss: 0.8849
Epoch 26/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 171ms/step - accuracy: 0.9381 - loss: 0.1694 - val_accuracy: 0.6680 - val_loss: 0.9731
Epoch 27/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 190ms/step - accuracy: 0.9624 - loss: 0.1118 - val_accuracy: 0.7040 - val_loss: 0.9450
Epoch 28/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 10s 190ms/step - accuracy: 0.9716 - loss: 0.0864 - val_accuracy: 0.7300 - val_loss: 1.0035
Epoch 29/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 10s 179ms/step - accuracy: 0.9721 - loss: 0.0809 - val_accuracy: 0.6900 - val_loss: 1.7237
Epoch 30/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 9s 143ms/step - accuracy: 0.9353 - loss: 0.1628 - val_accuracy: 0.7360 - val_loss: 1.2185
```

```
test_model = keras.models.load_model(
    "convnet_from_scratch_with_dropout.keras")
test_loss, test_acc = test_model.evaluate(test_dataset)
print(f"Test accuracy: {test_acc:.3f}")
```

```
16/16 ━━━━━━━━━━━━━━━━━━━━ 2s 92ms/step - accuracy: 0.6615 - loss: 0.6635
Test accuracy: 0.664
```

Model 1c: Using both Image Augmentation and Dropout mthod

```
data_augmentation = keras.Sequential(
    [
        layers.RandomFlip("horizontal"),
        layers.RandomRotation(0.1),
        layers.RandomZoom(0.2),
    ]
)


inputs = keras.Input(shape=(180, 180, 3))
x = data_augmentation(inputs)
x = layers.Rescaling(1./255)(x)
x = layers.Conv2D(filters=32, kernel_size=3, activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)
x = layers.Conv2D(filters=64, kernel_size=3, activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)
x = layers.Conv2D(filters=128, kernel_size=3, activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)
x = layers.Conv2D(filters=256, kernel_size=3, activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)
x = layers.Conv2D(filters=256, kernel_size=3, activation="relu")(x)
x = layers.Flatten()(x)
x = layers.Dropout(0.5)(x)
outputs = layers.Dense(1, activation="sigmoid")(x)
model = keras.Model(inputs=inputs, outputs=outputs)

model.compile(loss="binary_crossentropy",
              optimizer="rmsprop",
              metrics=["accuracy"])


callbacks = [
    keras.callbacks.ModelCheckpoint(
        filepath="convnet_from_scratch_with_augmentation_dropout.keras",
        save_best_only=True,
        monitor="val_loss")
]
history = model.fit(
    train_dataset,
    epochs=30,
    validation_data=validation_dataset,
    callbacks=callbacks)
```

```
Epoch 2/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 174ms/step - accuracy: 0.4889 - loss: 0.6943 - val_accuracy: 0.5000 - val_loss: 0.6927
Epoch 3/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 10s 160ms/step - accuracy: 0.4861 - loss: 0.6940 - val_accuracy: 0.5060 - val_loss: 0.6919
Epoch 4/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 190ms/step - accuracy: 0.5275 - loss: 0.6920 - val_accuracy: 0.5600 - val_loss: 0.6873
Epoch 5/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 186ms/step - accuracy: 0.5442 - loss: 0.6879 - val_accuracy: 0.5000 - val_loss: 0.7319
Epoch 6/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 10s 187ms/step - accuracy: 0.5297 - loss: 0.6964 - val_accuracy: 0.5860 - val_loss: 0.6790
Epoch 7/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 11s 212ms/step - accuracy: 0.6028 - loss: 0.6752 - val_accuracy: 0.6240 - val_loss: 0.6571
Epoch 8/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 193ms/step - accuracy: 0.6163 - loss: 0.6623 - val_accuracy: 0.6180 - val_loss: 0.6577
Epoch 9/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 184ms/step - accuracy: 0.6326 - loss: 0.6435 - val_accuracy: 0.6280 - val_loss: 0.6473
Epoch 10/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 11s 208ms/step - accuracy: 0.6724 - loss: 0.6371 - val_accuracy: 0.5460 - val_loss: 0.7497
Epoch 11/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 190ms/step - accuracy: 0.6485 - loss: 0.6304 - val_accuracy: 0.6320 - val_loss: 0.6823
Epoch 12/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 197ms/step - accuracy: 0.6483 - loss: 0.6449 - val_accuracy: 0.6000 - val_loss: 0.6348
Epoch 13/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 5s 155ms/step - accuracy: 0.6445 - loss: 0.6123 - val_accuracy: 0.6380 - val_loss: 0.6374
Epoch 14/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 5s 164ms/step - accuracy: 0.6701 - loss: 0.6309 - val_accuracy: 0.6640 - val_loss: 0.6255
Epoch 15/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 10s 152ms/step - accuracy: 0.6727 - loss: 0.5970 - val_accuracy: 0.6440 - val_loss: 0.6654
Epoch 16/30
```

```
32/32 ━━━━━━━━━━━━━━━━━━━━ 10s 198ms/step - accuracy: 0.6904 - loss: 0.5888 - val_accuracy: 0.6720 - val_loss: 0.6088
Epoch 18/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 179ms/step - accuracy: 0.7405 - loss: 0.5391 - val_accuracy: 0.6680 - val_loss: 0.5902
Epoch 19/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 12s 223ms/step - accuracy: 0.7441 - loss: 0.5356 - val_accuracy: 0.6980 - val_loss: 0.5843
Epoch 20/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 9s 181ms/step - accuracy: 0.7278 - loss: 0.5320 - val_accuracy: 0.6360 - val_loss: 0.6233
Epoch 21/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 181ms/step - accuracy: 0.6804 - loss: 0.5742 - val_accuracy: 0.6980 - val_loss: 0.5615
Epoch 22/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 11s 194ms/step - accuracy: 0.7343 - loss: 0.5494 - val_accuracy: 0.6820 - val_loss: 0.5874
Epoch 23/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 5s 165ms/step - accuracy: 0.7396 - loss: 0.5173 - val_accuracy: 0.6680 - val_loss: 0.6786
Epoch 24/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 201ms/step - accuracy: 0.7104 - loss: 0.5581 - val_accuracy: 0.7080 - val_loss: 0.5655
Epoch 25/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 5s 170ms/step - accuracy: 0.7514 - loss: 0.5413 - val_accuracy: 0.7320 - val_loss: 0.5456
Epoch 26/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 178ms/step - accuracy: 0.7310 - loss: 0.5131 - val_accuracy: 0.7260 - val_loss: 0.5824
Epoch 27/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 11s 195ms/step - accuracy: 0.7075 - loss: 0.5627 - val_accuracy: 0.6300 - val_loss: 0.7055
Epoch 28/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 7s 222ms/step - accuracy: 0.7313 - loss: 0.5493 - val_accuracy: 0.7280 - val_loss: 0.5427
Epoch 29/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 196ms/step - accuracy: 0.7176 - loss: 0.5136 - val_accuracy: 0.7340 - val_loss: 0.5235
Epoch 30/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 9s 162ms/step - accuracy: 0.7610 - loss: 0.4754 - val_accuracy: 0.7360 - val_loss: 0.5352
```

```
test_model = keras.models.load_model(
    "convnet_from_scratch_with_augmentation_dropout.keras")
test_loss, test_acc = test_model.evaluate(test_dataset)
print(f"Test accuracy: {test_acc:.3f}")
```

```
16/16 ━━━━━━━━━━━━━━━━━━━━ 2s 102ms/step - accuracy: 0.7453 - loss: 0.5599
Test accuracy: 0.696
```

Model 2) Increasing the Training sample size to 1500.Including Maxpooling,Data Augmentation and Dropout technique with dropout rate of 0.5

```
import os
import shutil
import pathlib

# Define original folders (your dataset path)
original_train_dir = pathlib.Path("/content/drive/MyDrive/AML/cats_vs_dogs_small/train")
original_val_dir = pathlib.Path("/content/drive/MyDrive/AML/cats_vs_dogs_small/validation")
original_test_dir = pathlib.Path("/content/drive/MyDrive/AML/cats_vs_dogs_small/test")

# Destination for balanced dataset subsets
new_base_dir = pathlib.Path("/content/drive/MyDrive/AML/cats_vs_dogs_small_subset")

def make_subset_from_folder(subset_name, original_folder, start_index, end_index):
    print(f"\nCreating '{subset_name}' subset from {original_folder} [{start_index}:{end_index}]")

    for category in ["cats", "dogs"]:
        src_dir = original_folder / category
        dest_dir = new_base_dir / subset_name / category

        # Clean old files if they exist
        if dest_dir.exists():
            shutil.rmtree(dest_dir)

        os.makedirs(dest_dir, exist_ok=True)

        files = sorted(os.listdir(src_dir))

        # Validate end_index
        if end_index > len(files):
            print(f" WARNING: end_index {end_index} exceeds available files ({len(files)}). Adjusting.")
            end_index = len(files)

        subset_files = files[start_index:end_index]
        print(f"Copying {len(subset_files)} '{category}' images to '{dest_dir}'...")

        for fname in subset_files:
            src_file = src_dir / fname
            dst_file = dest_dir / fname
            shutil.copyfile(src_file, dst_file)

    print(f" Subset '{subset_name}' created.")

def main():
    # 1500 train: 750 cats + 750 dogs
```

```
    make_subset_from_folder("train", original_train_dir, 0, 750)

    # 600 validation: 300 cats + 300 dogs
    make_subset_from_folder("validation", original_val_dir, 0, 300)

    # 600 test: 300 cats + 300 dogs
    make_subset_from_folder("test", original_test_dir, 0, 300)

if __name__ == "__main__":
    main()
```

```
Creating 'train' subset from /content/drive/MyDrive/AML/cats_vs_dogs_small/train [0:750]
Copying 750 'cats' images to '/content/drive/MyDrive/AML/cats_vs_dogs_small_subset/train/cats'...
Copying 750 'dogs' images to '/content/drive/MyDrive/AML/cats_vs_dogs_small_subset/train/dogs'...
✅ Subset 'train' created.

Creating 'validation' subset from /content/drive/MyDrive/AML/cats_vs_dogs_small/validation [0:300]
Copying 300 'cats' images to '/content/drive/MyDrive/AML/cats_vs_dogs_small_subset/validation/cats'...
Copying 300 'dogs' images to '/content/drive/MyDrive/AML/cats_vs_dogs_small_subset/validation/dogs'...
✅ Subset 'validation' created.

Creating 'test' subset from /content/drive/MyDrive/AML/cats_vs_dogs_small/test [0:300]
Copying 300 'cats' images to '/content/drive/MyDrive/AML/cats_vs_dogs_small_subset/test/cats'...
Copying 300 'dogs' images to '/content/drive/MyDrive/AML/cats_vs_dogs_small_subset/test/dogs'...
✅ Subset 'test' created.
```

```
from tensorflow.keras.utils import image_dataset_from_directory
from pathlib import Path

new_base_dir = Path("/content/drive/MyDrive/AML/cats_vs_dogs_small_subset")

train_dataset = image_dataset_from_directory(
    new_base_dir / "train",
    image_size=(180, 180),
    batch_size=32
)

validation_dataset = image_dataset_from_directory(
    new_base_dir / "validation",
    image_size=(180, 180),
    batch_size=32
)

test_dataset = image_dataset_from_directory(
    new_base_dir / "test",
    image_size=(180, 180),
    batch_size=32
)

# Prefetch for speed
AUTOTUNE = tf.data.AUTOTUNE
train_dataset = train_dataset.prefetch(buffer_size=AUTOTUNE)
validation_dataset = validation_dataset.prefetch(buffer_size=AUTOTUNE)
test_dataset = test_dataset.prefetch(buffer_size=AUTOTUNE)
```

```
Found 1500 files belonging to 2 classes.
Found 600 files belonging to 2 classes.
Found 600 files belonging to 2 classes.
```

Defining a new convnet that includes image augmentation and dropout

```
inputs = keras.Input(shape=(180, 180, 3))
x = data_augmentation(inputs)
x = layers.Rescaling(1./255)(inputs)
x = layers.Conv2D(filters=32, kernel_size=3, activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)
x = layers.Conv2D(filters=64, kernel_size=3, activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)
x = layers.Conv2D(filters=128, kernel_size=3, activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)
x = layers.Conv2D(filters=256, kernel_size=3, activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)
x = layers.Conv2D(filters=256, kernel_size=3, activation="relu")(x)
x = layers.Flatten()(x)
x = layers.Dropout(0.5)(x)
outputs = layers.Dense(1, activation="sigmoid")(x)
model = keras.Model(inputs=inputs, outputs=outputs)
```

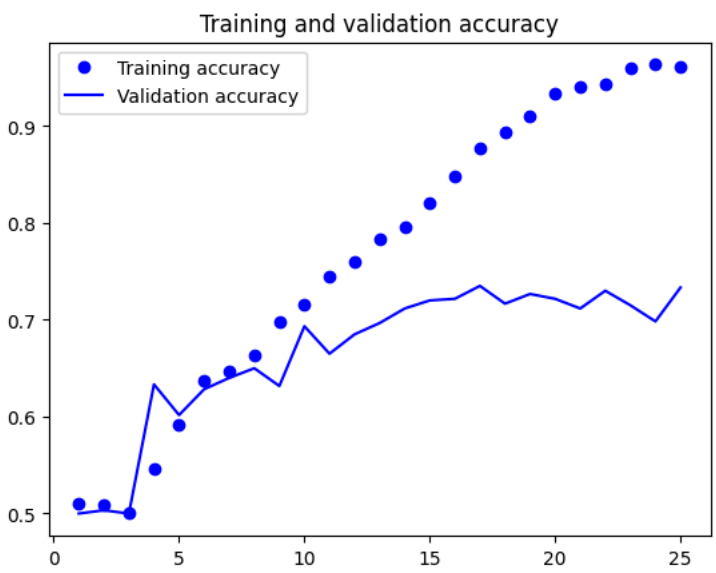
```
model.compile(loss="binary_crossentropy",
              optimizer="rmsprop",
              metrics=["accuracy"])


from tensorflow import keras
from tensorflow.keras import layers
import matplotlib.pyplot as plt
from keras.callbacks import EarlyStopping
from keras import regularizers

# used early stopping to stop optimization when it isn't helping any more.
early_stopping_monitor = EarlyStopping(patience=10)


data_augmentation = keras.Sequential(
    [
        layers.RandomFlip("horizontal"),
        layers.RandomRotation(0.1),
        layers.RandomZoom(0.2),
    ]
)



plt.figure(figsize=(10, 10))
for images, _ in train_dataset.take(1):
    for i in range(9):
        augmented_images = data_augmentation(images)
        ax = plt.subplot(3, 3, i + 1)
        plt.imshow(augmented_images[0].numpy().astype("uint8"))
        plt.axis("off")
```

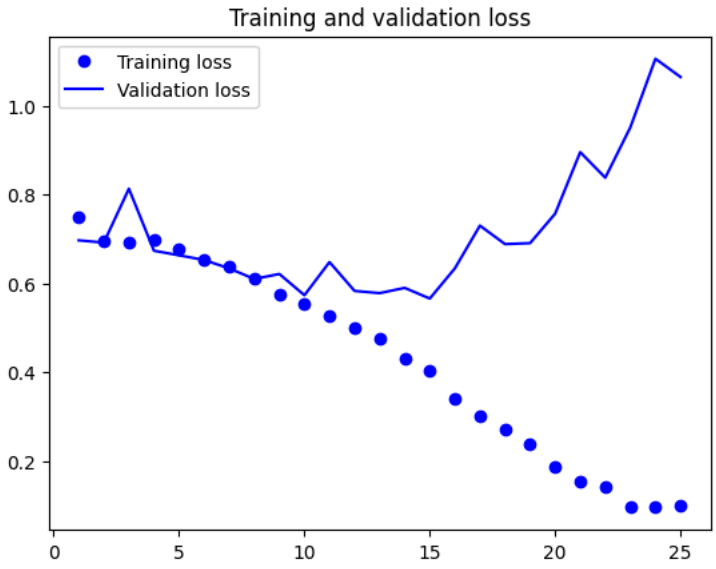
```
callbacks = [
    keras.callbacks.ModelCheckpoint(
        filepath="convnet_from_scratch.keras",
        save_best_only=True,
        monitor="val_loss"), early_stopping_monitor
]
history = model.fit(
```

```
    train_dataset,
    epochs=30,
    validation_data=validation_dataset,
    callbacks=callbacks)
```

```
Epoch 1/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 19s 297ms/step - accuracy: 0.5040 - loss: 0.8771 - val_accuracy: 0.5000 - val_loss: 0.6973
Epoch 2/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 8s 171ms/step - accuracy: 0.4966 - loss: 0.6954 - val_accuracy: 0.5033 - val_loss: 0.6921
Epoch 3/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 7s 160ms/step - accuracy: 0.5039 - loss: 0.6931 - val_accuracy: 0.5000 - val_loss: 0.8135
Epoch 4/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 10s 164ms/step - accuracy: 0.5357 - loss: 0.7113 - val_accuracy: 0.6333 - val_loss: 0.6739
Epoch 5/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 11s 173ms/step - accuracy: 0.5707 - loss: 0.6809 - val_accuracy: 0.6017 - val_loss: 0.6637
Epoch 6/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 12s 216ms/step - accuracy: 0.6440 - loss: 0.6583 - val_accuracy: 0.6283 - val_loss: 0.6530
Epoch 7/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 7s 151ms/step - accuracy: 0.6293 - loss: 0.6469 - val_accuracy: 0.6400 - val_loss: 0.6341
Epoch 8/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 10s 152ms/step - accuracy: 0.6791 - loss: 0.5949 - val_accuracy: 0.6500 - val_loss: 0.6103
Epoch 9/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 9s 193ms/step - accuracy: 0.6958 - loss: 0.5725 - val_accuracy: 0.6317 - val_loss: 0.6216
Epoch 10/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 8s 155ms/step - accuracy: 0.7140 - loss: 0.5517 - val_accuracy: 0.6933 - val_loss: 0.5737
Epoch 11/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 10s 161ms/step - accuracy: 0.7427 - loss: 0.5354 - val_accuracy: 0.6650 - val_loss: 0.6483
Epoch 12/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 9s 184ms/step - accuracy: 0.7659 - loss: 0.4897 - val_accuracy: 0.6850 - val_loss: 0.5834
Epoch 13/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 10s 180ms/step - accuracy: 0.7704 - loss: 0.5031 - val_accuracy: 0.6967 - val_loss: 0.5785
Epoch 14/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 9s 162ms/step - accuracy: 0.8111 - loss: 0.4059 - val_accuracy: 0.7117 - val_loss: 0.5903
Epoch 15/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 8s 177ms/step - accuracy: 0.8238 - loss: 0.3858 - val_accuracy: 0.7200 - val_loss: 0.5662
Epoch 16/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 9s 182ms/step - accuracy: 0.8642 - loss: 0.3256 - val_accuracy: 0.7217 - val_loss: 0.6342
Epoch 17/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 8s 170ms/step - accuracy: 0.8832 - loss: 0.2952 - val_accuracy: 0.7350 - val_loss: 0.7304
Epoch 18/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 9s 182ms/step - accuracy: 0.8984 - loss: 0.2597 - val_accuracy: 0.7167 - val_loss: 0.6889
Epoch 19/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 10s 178ms/step - accuracy: 0.9106 - loss: 0.2286 - val_accuracy: 0.7267 - val_loss: 0.6909
Epoch 20/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 10s 168ms/step - accuracy: 0.9509 - loss: 0.1593 - val_accuracy: 0.7217 - val_loss: 0.7573
Epoch 21/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 10s 168ms/step - accuracy: 0.9424 - loss: 0.1561 - val_accuracy: 0.7117 - val_loss: 0.8958
Epoch 22/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 10s 170ms/step - accuracy: 0.9529 - loss: 0.1217 - val_accuracy: 0.7300 - val_loss: 0.8383
Epoch 23/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 9s 182ms/step - accuracy: 0.9668 - loss: 0.0847 - val_accuracy: 0.7150 - val_loss: 0.9517
Epoch 24/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 10s 170ms/step - accuracy: 0.9704 - loss: 0.0901 - val_accuracy: 0.6983 - val_loss: 1.1060
Epoch 25/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 9s 184ms/step - accuracy: 0.9645 - loss: 0.0917 - val_accuracy: 0.7333 - val_loss: 1.0650
```

```
accuracy = history.history["accuracy"]
val_accuracy = history.history["val_accuracy"]
loss = history.history["loss"]
val_loss = history.history["val_loss"]
epochs = range(1, len(accuracy) + 1)
plt.plot(epochs, accuracy, "bo", label="Training accuracy")
plt.plot(epochs, val_accuracy, "b", label="Validation accuracy")
plt.title("Training and validation accuracy")
plt.legend()
plt.figure()
plt.plot(epochs, loss, "bo", label="Training loss")
plt.plot(epochs, val_loss, "b", label="Validation loss")
plt.title("Training and validation loss")
plt.legend()
plt.show()
```






```
test_model = keras.models.load_model("convnet_from_scratch.keras")
test_loss, test_acc = test_model.evaluate(test_dataset)
print(f"Test accuracy: {test_acc:.3f}")
```

```
19/19 ━━━━━━━━━━━━━━━━━━━━ 3s 96ms/step - accuracy: 0.7006 - loss: 0.6534
Test accuracy: 0.705
```

Model 3: Increasing the Training sample size to 1700

```
import os
import shutil
import pathlib
import tensorflow as tf
from tensorflow import keras
from tensorflow.keras.utils import image_dataset_from_directory

# 1. Function to Create Subsets
def make_subset(subset_name, original_dir, new_base_dir, start_index, end_index):
    print(f"\nCreating subset: {subset_name} from {original_dir} [{start_index}:{end_index}]")

    for category in ["cats", "dogs"]:
        src_dir = original_dir / category
        dest_dir = new_base_dir / subset_name / category

        if dest_dir.exists():
            shutil.rmtree(dest_dir)

        os.makedirs(dest_dir, exist_ok=True)

        files = sorted(os.listdir(src_dir))

        if end_index > len(files):
            print(f"⚠️ end_index {end_index} exceeds available files ({len(files)}). Adjusting...")
            end_index = len(files)
```

```
            end_index = len(files)

            subset_files = files[start_index:end_index]

            print(f"Copying {len(subset_files)} files from {src_dir} to {dest_dir}...")

            for fname in subset_files:
                src_file = src_dir / fname
                dst_file = dest_dir / fname

                shutil.copyfile(src_file, dst_file)

        print(f"Subset '{subset_name}' created successfully!")

    # 2. Paths Setup
    original_train_dir = pathlib.Path("/content/drive/MyDrive/AML/cats_vs_dogs_small/train")
    original_val_dir = pathlib.Path("/content/drive/MyDrive/AML/cats_vs_dogs_small/validation")
    original_test_dir = pathlib.Path("/content/drive/MyDrive/AML/cats_vs_dogs_small/test")

    new_base_dir = pathlib.Path("/content/drive/MyDrive/AML/cats_vs_dogs_small_subset")

    # 3. Create Subsets
    make_subset("train_4", original_train_dir, new_base_dir, 0, 850)
    make_subset("validation_4", original_val_dir, new_base_dir, 0, 250)
    make_subset("test_4", original_test_dir, new_base_dir, 0, 250)

    # 4. Load the Subset Datasets
    train_dataset_4 = image_dataset_from_directory(
        new_base_dir / "train_4",
        image_size=(180, 180),
        batch_size=32
    )

    validation_dataset_4 = image_dataset_from_directory(
        new_base_dir / "validation_4",
        image_size=(180, 180),
        batch_size=32
    )

    test_dataset_4 = image_dataset_from_directory(
        new_base_dir / "test_4",
        image_size=(180, 180),
        batch_size=32
    )

    # 5. Define the Callbacks
    early_stopping_monitor = keras.callbacks.EarlyStopping(
        monitor="val_loss",
        patience=3,
        restore_best_weights=True
    )

    callbacks = [
        keras.callbacks.ModelCheckpoint(
            filepath="convnet_from_scratch.keras",
            save_best_only=True,
            monitor="val_loss"
        ),
        early_stopping_monitor
    ]

    # 6. Build Your Model
    model = keras.Sequential([
        keras.layers.Rescaling(1./255, input_shape=(180, 180, 3)),
        keras.layers.Conv2D(32, (3, 3), activation='relu'),
        keras.layers.MaxPooling2D(),
        keras.layers.Conv2D(64, (3, 3), activation='relu'),
        keras.layers.MaxPooling2D(),
        keras.layers.Conv2D(128, (3, 3), activation='relu'),
        keras.layers.MaxPooling2D(),
        keras.layers.Flatten(),
        keras.layers.Dropout(0.5),
        keras.layers.Dense(512, activation='relu'),
        keras.layers.Dense(1, activation='sigmoid')
    ])

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

    # 7. Train the Model
    history = model.fit(
```

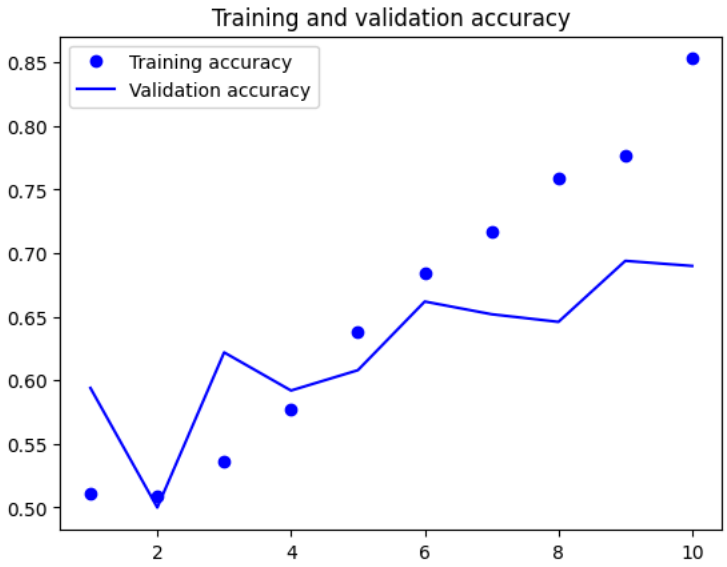
```
history = model.fit(
    train_dataset_4,
    epochs=30,
    validation_data=validation_dataset_4,
    callbacks=callbacks
)
```

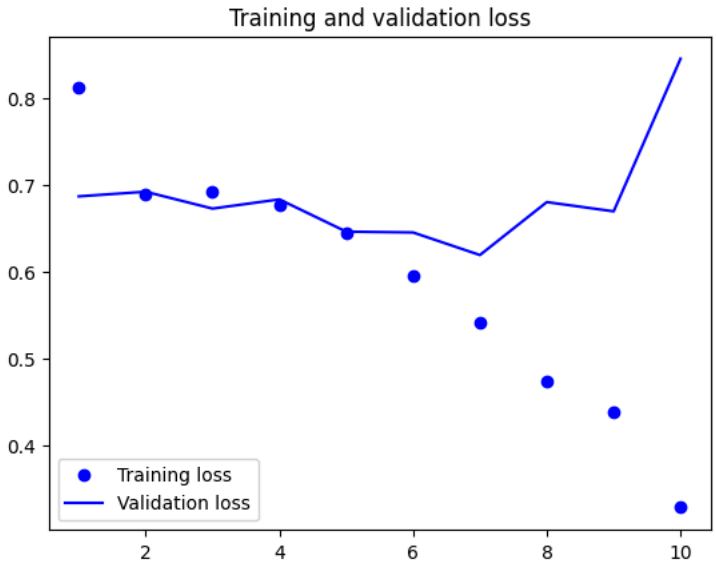
```
Creating subset: train_4 from /content/drive/MyDrive/AML/cats_vs_dogs_small/train [0:850]
Copying 850 files from /content/drive/MyDrive/AML/cats_vs_dogs_small/train/cats to /content/drive/MyDrive/AML/cats_vs_do
Copying 850 files from /content/drive/MyDrive/AML/cats_vs_dogs_small/train/dogs to /content/drive/MyDrive/AML/cats_vs_do
✅ Subset 'train_4' created successfully!

Creating subset: validation_4 from /content/drive/MyDrive/AML/cats_vs_dogs_small/validation [0:250]
Copying 250 files from /content/drive/MyDrive/AML/cats_vs_dogs_small/validation/cats to /content/drive/MyDrive/AML/cats_
Copying 250 files from /content/drive/MyDrive/AML/cats_vs_dogs_small/validation/dogs to /content/drive/MyDrive/AML/cats_
✅ Subset 'validation_4' created successfully!

Creating subset: test_4 from /content/drive/MyDrive/AML/cats_vs_dogs_small/test [0:250]
Copying 250 files from /content/drive/MyDrive/AML/cats_vs_dogs_small/test/cats to /content/drive/MyDrive/AML/cats_vs_dog
Copying 250 files from /content/drive/MyDrive/AML/cats_vs_dogs_small/test/dogs to /content/drive/MyDrive/AML/cats_vs_dog
✅ Subset 'test_4' created successfully!
Found 1700 files belonging to 2 classes.
Found 500 files belonging to 2 classes.
Found 500 files belonging to 2 classes.
Epoch 1/30
/usr/local/lib/python3.11/dist-packages/keras/src/layers/preprocessing/tf_data_layer.py:19: UserWarning: Do not pass an
  super().__init__(**kwargs)
54/54 ━━━━━━━━━━━━━━━━━━━━ 22s 293ms/step - accuracy: 0.5070 - loss: 1.0374 - val_accuracy: 0.5940 - val_loss: 0.6870
Epoch 2/30
54/54 ━━━━━━━━━━━━━━━━━━━━ 10s 192ms/step - accuracy: 0.5158 - loss: 0.6891 - val_accuracy: 0.5000 - val_loss: 0.6923
Epoch 3/30
54/54 ━━━━━━━━━━━━━━━━━━━━ 20s 191ms/step - accuracy: 0.5276 - loss: 0.6942 - val_accuracy: 0.6220 - val_loss: 0.6729
Epoch 4/30
54/54 ━━━━━━━━━━━━━━━━━━━━ 19s 157ms/step - accuracy: 0.5965 - loss: 0.6696 - val_accuracy: 0.5920 - val_loss: 0.6835
Epoch 5/30
54/54 ━━━━━━━━━━━━━━━━━━━━ 16s 305ms/step - accuracy: 0.6088 - loss: 0.6624 - val_accuracy: 0.6080 - val_loss: 0.6463
Epoch 6/30
54/54 ━━━━━━━━━━━━━━━━━━━━ 10s 189ms/step - accuracy: 0.6745 - loss: 0.6144 - val_accuracy: 0.6620 - val_loss: 0.6453
Epoch 7/30
54/54 ━━━━━━━━━━━━━━━━━━━━ 11s 201ms/step - accuracy: 0.7066 - loss: 0.5574 - val_accuracy: 0.6520 - val_loss: 0.6193
Epoch 8/30
54/54 ━━━━━━━━━━━━━━━━━━━━ 9s 162ms/step - accuracy: 0.7519 - loss: 0.4839 - val_accuracy: 0.6460 - val_loss: 0.6804
Epoch 9/30
54/54 ━━━━━━━━━━━━━━━━━━━━ 9s 141ms/step - accuracy: 0.7442 - loss: 0.4786 - val_accuracy: 0.6940 - val_loss: 0.6697
Epoch 10/30
54/54 ━━━━━━━━━━━━━━━━━━━━ 10s 176ms/step - accuracy: 0.8376 - loss: 0.3515 - val_accuracy: 0.6900 - val_loss: 0.8457
```

```
inputs = keras.Input(shape=(180, 180, 3))
x = data_augmentation(inputs)
x = layers.Rescaling(1./255)(inputs)
x = layers.Conv2D(filters=32, kernel_size=3, activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)
x = layers.Conv2D(filters=64, kernel_size=3, activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)
x = layers.Conv2D(filters=128, kernel_size=3, activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)
x = layers.Conv2D(filters=256, kernel_size=3, activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)
x = layers.Conv2D(filters=256, kernel_size=3, activation="relu")(x)
x = layers.Flatten()(x)
x = layers.Dropout(0.5)(x)
outputs = layers.Dense(1, activation="sigmoid")(x)
model = keras.Model(inputs=inputs, outputs=outputs)

model.compile(loss="binary_crossentropy",
              optimizer="rmsprop",
              metrics=["accuracy"])


data_augmentation = keras.Sequential(
    [
        layers.RandomFlip("horizontal"),
        layers.RandomRotation(0.1),
        layers.RandomZoom(0.2),
    ]
)



plt.figure(figsize=(10, 10))
for images, _ in train_dataset.take(1):
    for i in range(9):
        augmented_images = data_augmentation(images)
```

```
    ax = plt.subplot(3, 3, i + 1)
    plt.imshow(augmented_images[0].numpy().astype("uint8"))
    plt.axis("off")
```

```
accuracy = history.history["accuracy"]
val_accuracy = history.history["val_accuracy"]
loss = history.history["loss"]
val_loss = history.history["val_loss"]
epochs = range(1, len(accuracy) + 1)
plt.plot(epochs, accuracy, "bo", label="Training accuracy")
plt.plot(epochs, val_accuracy, "b", label="Validation accuracy")
plt.title("Training and validation accuracy")
plt.legend()
plt.figure()
plt.plot(epochs, loss, "bo", label="Training loss")
plt.plot(epochs, val_loss, "b", label="Validation loss")
plt.title("Training and validation loss")
plt.legend()
plt.show()
```






```
test_model = keras.models.load_model("convnet_from_scratch.keras")
test_loss, test_acc = test_model.evaluate(test_dataset_4)
print(f"Test accuracy: {test_acc:.3f}")
```

```
16/16 ━━━━━━━━━━━━━━━━━━━━ 2s 98ms/step - accuracy: 0.6135 - loss: 0.6971
Test accuracy: 0.620
```

Feature extraction together with data augmentation

Instantiating and freezing the VGG16 convolutional base

Pre-Trained Model - 1000 Training samples

```
conv_base  = keras.applications.vgg16.VGG16(
    weights="imagenet",
    include_top=False,
    input_shape=(180, 180, 3))
```

```
Downloading data from https://storage.googleapis.com/tensorflow/keras-applications/vgg16/vgg16_weights_tf_dim_ordering_t
58889256/58889256 ━━━━━━━━━━━━━━━━━━━━ 0s 0us/step
```

```
conv_base.summary()
```

Model: "vgg16"

Layer (type)	Output Shape	Param #
input_layer_13 (InputLayer)	(None, 180, 180, 3)	0
block1_conv1 (Conv2D)	(None, 180, 180, 64)	1,792
block1_conv2 (Conv2D)	(None, 180, 180, 64)	36,928
block1_pool (MaxPooling2D)	(None, 90, 90, 64)	0
block2_conv1 (Conv2D)	(None, 90, 90, 128)	73,856
block2_conv2 (Conv2D)	(None, 90, 90, 128)	147,584
block2_pool (MaxPooling2D)	(None, 45, 45, 128)	0
block3_conv1 (Conv2D)	(None, 45, 45, 256)	295,168
block3_conv2 (Conv2D)	(None, 45, 45, 256)	590,080
block3_conv3 (Conv2D)	(None, 45, 45, 256)	590,080
block3_pool (MaxPooling2D)	(None, 22, 22, 256)	0
block4_conv1 (Conv2D)	(None, 22, 22, 512)	1,180,160
block4_conv2 (Conv2D)	(None, 22, 22, 512)	2,359,808
block4_conv3 (Conv2D)	(None, 22, 22, 512)	2,359,808
block4_pool (MaxPooling2D)	(None, 11, 11, 512)	0
block5_conv1 (Conv2D)	(None, 11, 11, 512)	2,359,808
block5_conv2 (Conv2D)	(None, 11, 11, 512)	2,359,808
block5_conv3 (Conv2D)	(None, 11, 11, 512)	2,359,808
block5_pool (MaxPooling2D)	(None, 5, 5, 512)	0

Total params: 14,714,688 (56.13 MB)
Trainable params: 14,714,688 (56.13 MB)
Non-trainable params: 0 (0.00 B)

```
conv_base  = keras.applications.vgg16.VGG16(
    weights="imagenet",
    include_top=False)
```

```
conv_base.trainable = True
for layer in conv_base.layers[:-4]:
    layer.trainable = False
```

Adding a data augmentation stage and a classifier to the convolutional base

```
data_augmentation = keras.Sequential(
    [
        layers.RandomFlip("horizontal"),
        layers.RandomRotation(0.1),
        layers.RandomZoom(0.2),
    ]
)
```

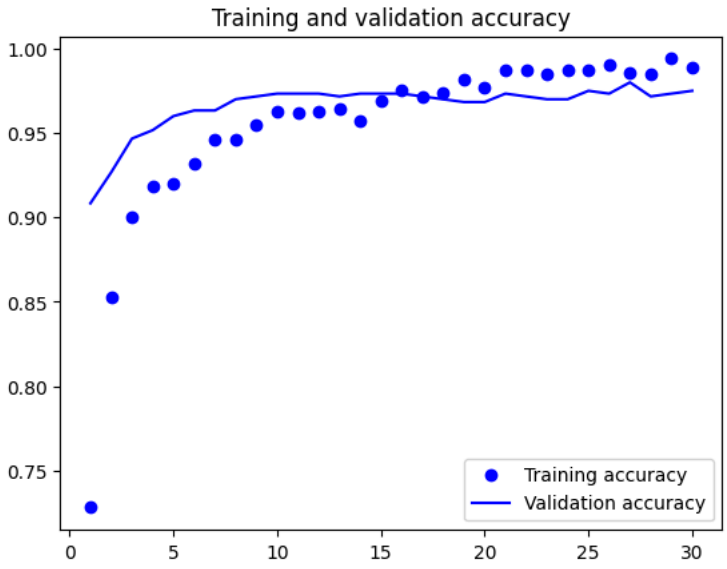
```
inputs = keras.Input(shape=(180, 180, 3))
x = data_augmentation(inputs)
x = keras.applications.vgg16.preprocess_input(x)
x = conv_base(x)
x = layers.Flatten()(x)
x = layers.Dense(256)(x)
x = layers.Dropout(0.5)(x)
outputs = layers.Dense(1, activation="sigmoid")(x)
model = keras.Model(inputs, outputs)
model.compile(loss="binary_crossentropy",
              optimizer=keras.optimizers.RMSprop(learning_rate=1e-5),
              metrics=["accuracy"])
```

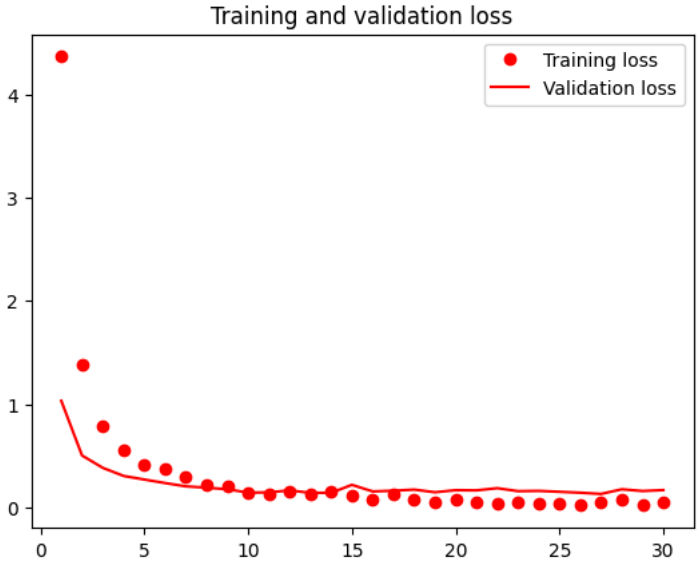
```
callbacks = [
    keras.callbacks.ModelCheckpoint(
        filepath="fine_tuning.keras",
        save_best_only=True,
        monitor="val_loss")
]
history = model.fit(
```

```
    train_dataset,
    epochs=30,
    validation_data=validation_dataset,
    callbacks=callbacks)
```

```
Epoch 1/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 18s 289ms/step - accuracy: 0.6527 - loss: 6.6579 - val_accuracy: 0.9083 - val_loss: 1.0326
Epoch 2/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 14s 189ms/step - accuracy: 0.8351 - loss: 1.6189 - val_accuracy: 0.9267 - val_loss: 0.5032
Epoch 3/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 11s 197ms/step - accuracy: 0.8742 - loss: 1.0359 - val_accuracy: 0.9467 - val_loss: 0.3834
Epoch 4/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 10s 200ms/step - accuracy: 0.9015 - loss: 0.6770 - val_accuracy: 0.9517 - val_loss: 0.3052
Epoch 5/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 9s 185ms/step - accuracy: 0.9178 - loss: 0.3953 - val_accuracy: 0.9600 - val_loss: 0.2702
Epoch 6/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 10s 207ms/step - accuracy: 0.9236 - loss: 0.3897 - val_accuracy: 0.9633 - val_loss: 0.2361
Epoch 7/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 22s 243ms/step - accuracy: 0.9547 - loss: 0.2364 - val_accuracy: 0.9633 - val_loss: 0.2040
Epoch 8/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 9s 187ms/step - accuracy: 0.9494 - loss: 0.2120 - val_accuracy: 0.9700 - val_loss: 0.1913
Epoch 9/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 9s 167ms/step - accuracy: 0.9511 - loss: 0.2429 - val_accuracy: 0.9717 - val_loss: 0.1762
Epoch 10/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 11s 189ms/step - accuracy: 0.9620 - loss: 0.1499 - val_accuracy: 0.9733 - val_loss: 0.1433
Epoch 11/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 10s 191ms/step - accuracy: 0.9679 - loss: 0.1199 - val_accuracy: 0.9733 - val_loss: 0.1457
Epoch 12/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 12s 232ms/step - accuracy: 0.9587 - loss: 0.2294 - val_accuracy: 0.9733 - val_loss: 0.1653
Epoch 13/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 18s 170ms/step - accuracy: 0.9712 - loss: 0.1122 - val_accuracy: 0.9717 - val_loss: 0.1409
Epoch 14/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 11s 185ms/step - accuracy: 0.9569 - loss: 0.1681 - val_accuracy: 0.9733 - val_loss: 0.1419
Epoch 15/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 9s 183ms/step - accuracy: 0.9655 - loss: 0.1274 - val_accuracy: 0.9733 - val_loss: 0.2186
Epoch 16/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 10s 170ms/step - accuracy: 0.9765 - loss: 0.0849 - val_accuracy: 0.9733 - val_loss: 0.1551
Epoch 17/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 10s 168ms/step - accuracy: 0.9743 - loss: 0.1204 - val_accuracy: 0.9717 - val_loss: 0.1618
Epoch 18/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 10s 164ms/step - accuracy: 0.9767 - loss: 0.0668 - val_accuracy: 0.9700 - val_loss: 0.1724
Epoch 19/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 11s 181ms/step - accuracy: 0.9798 - loss: 0.0516 - val_accuracy: 0.9683 - val_loss: 0.1470
Epoch 20/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 10s 176ms/step - accuracy: 0.9755 - loss: 0.0783 - val_accuracy: 0.9683 - val_loss: 0.1670
Epoch 21/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 10s 164ms/step - accuracy: 0.9859 - loss: 0.0465 - val_accuracy: 0.9733 - val_loss: 0.1652
Epoch 22/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 10s 169ms/step - accuracy: 0.9892 - loss: 0.0295 - val_accuracy: 0.9717 - val_loss: 0.1866
Epoch 23/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 11s 183ms/step - accuracy: 0.9870 - loss: 0.0362 - val_accuracy: 0.9700 - val_loss: 0.1576
Epoch 24/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 9s 181ms/step - accuracy: 0.9866 - loss: 0.0281 - val_accuracy: 0.9700 - val_loss: 0.1601
Epoch 25/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 7s 153ms/step - accuracy: 0.9849 - loss: 0.0519 - val_accuracy: 0.9750 - val_loss: 0.1514
Epoch 26/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 10s 152ms/step - accuracy: 0.9959 - loss: 0.0156 - val_accuracy: 0.9733 - val_loss: 0.1425
Epoch 27/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 9s 201ms/step - accuracy: 0.9882 - loss: 0.0408 - val_accuracy: 0.9800 - val_loss: 0.1307
Epoch 28/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 8s 172ms/step - accuracy: 0.9895 - loss: 0.0506 - val_accuracy: 0.9717 - val_loss: 0.1756
Epoch 29/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 8s 177ms/step - accuracy: 0.9944 - loss: 0.0240 - val_accuracy: 0.9733 - val_loss: 0.1590
```

```
import matplotlib.pyplot as plt
accuracy = history.history["accuracy"]
val_accuracy = history.history["val_accuracy"]
loss = history.history["loss"]
val_loss = history.history["val_loss"]
epochs = range(1, len(accuracy) + 1)
plt.plot(epochs, accuracy, "bo", label="Training accuracy")
plt.plot(epochs, val_accuracy, "b", label="Validation accuracy")
plt.title("Training and validation accuracy")
plt.legend()
plt.figure()
plt.plot(epochs, loss, "ro", label="Training loss")
plt.plot(epochs, val_loss, "r", label="Validation loss")
plt.title("Training and validation loss")
plt.legend()
plt.show()
```






```
model = keras.models.load_model("fine_tuning.keras")
test_loss, test_acc = model.evaluate(test_dataset)
print(f"Test accuracy: {test_acc:.3f}")
```

```
19/19 ━━━━━━━━━━━━━━━━━━━━ 3s 101ms/step - accuracy: 0.9706 - loss: 0.2744
Test accuracy: 0.968
```

Pre-Trained Model - 1500 Training samples

```
conv_base  = keras.applications.vgg16.VGG16(
    weights="imagenet",
    include_top=False,
    input_shape=(180, 180, 3))


conv_base  = keras.applications.vgg16.VGG16(
    weights="imagenet",
    include_top=False)

conv_base.trainable = True
for layer in conv_base.layers[:-4]:
    layer.trainable = False


data_augmentation = keras.Sequential(
    [
        layers.RandomFlip("horizontal"),
        layers.RandomRotation(0.1),
        layers.RandomZoom(0.2),
    ]
)
```

```
inputs = keras.Input(shape=(180, 180, 3))
x = data_augmentation(inputs)
x = keras.applications.vgg16.preprocess_input(x)
x = conv_base(x)
x = layers.Flatten()(x)
x = layers.Dense(256)(x)
x = layers.Dropout(0.5)(x)
outputs = layers.Dense(1, activation="sigmoid")(x)
model = keras.Model(inputs, outputs)
model.compile(loss="binary_crossentropy",
              optimizer=keras.optimizers.RMSprop(learning_rate=1e-5),
              metrics=["accuracy"])
```

```
callbacks = [
    keras.callbacks.ModelCheckpoint(
        filepath="fine_tuning2.keras",
        save_best_only=True,
        monitor="val_loss")
]
history = model.fit(
    train_dataset,
    epochs=10,
    validation_data=validation_dataset,
    callbacks=callbacks)
```

```
Epoch 1/10
47/47 ━━━━━━━━━━━━━━━━━━━━ 13s 284ms/step - accuracy: 0.9547 - loss: 0.1862 - val_accuracy: 0.9650 - val_loss: 0.2023
Epoch 2/10
47/47 ━━━━━━━━━━━━━━━━━━━━ 11s 224ms/step - accuracy: 0.9537 - loss: 0.2013 - val_accuracy: 0.9667 - val_loss: 0.2331
Epoch 3/10
47/47 ━━━━━━━━━━━━━━━━━━━━ 17s 166ms/step - accuracy: 0.9573 - loss: 0.1198 - val_accuracy: 0.9667 - val_loss: 0.2546
Epoch 4/10
47/47 ━━━━━━━━━━━━━━━━━━━━ 11s 191ms/step - accuracy: 0.9638 - loss: 0.1789 - val_accuracy: 0.9667 - val_loss: 0.2199
Epoch 5/10
47/47 ━━━━━━━━━━━━━━━━━━━━ 10s 182ms/step - accuracy: 0.9718 - loss: 0.0955 - val_accuracy: 0.9667 - val_loss: 0.2299
Epoch 6/10
47/47 ━━━━━━━━━━━━━━━━━━━━ 10s 178ms/step - accuracy: 0.9609 - loss: 0.1488 - val_accuracy: 0.9683 - val_loss: 0.2285
Epoch 7/10
47/47 ━━━━━━━━━━━━━━━━━━━━ 10s 174ms/step - accuracy: 0.9690 - loss: 0.1466 - val_accuracy: 0.9683 - val_loss: 0.2194
Epoch 8/10
47/47 ━━━━━━━━━━━━━━━━━━━━ 9s 193ms/step - accuracy: 0.9747 - loss: 0.0786 - val_accuracy: 0.9700 - val_loss: 0.2320
Epoch 9/10
47/47 ━━━━━━━━━━━━━━━━━━━━ 10s 192ms/step - accuracy: 0.9790 - loss: 0.0690 - val_accuracy: 0.9700 - val_loss: 0.2194
Epoch 10/10
47/47 ━━━━━━━━━━━━━━━━━━━━ 10s 181ms/step - accuracy: 0.9781 - loss: 0.1182 - val_accuracy: 0.9733 - val_loss: 0.2140
```

```
model = keras.models.load_model("fine_tuning2.keras")
test_loss, test_acc = model.evaluate(test_dataset)
print(f"Test accuracy: {test_acc:.3f}")
```

```
19/19 ━━━━━━━━━━━━━━━━━━━━ 3s 112ms/step - accuracy: 0.9655 - loss: 0.2444
Test accuracy: 0.970
```

Pre-Trained Model - 1700 samples

```
conv_base  = keras.applications.vgg16.VGG16(
    weights="imagenet",
    include_top=False,
    input_shape=(180, 180, 3))
```

```
conv_base  = keras.applications.vgg16.VGG16(
    weights="imagenet",
    include_top=False)

conv_base.trainable = True
for layer in conv_base.layers[:-4]:
    layer.trainable = False
```

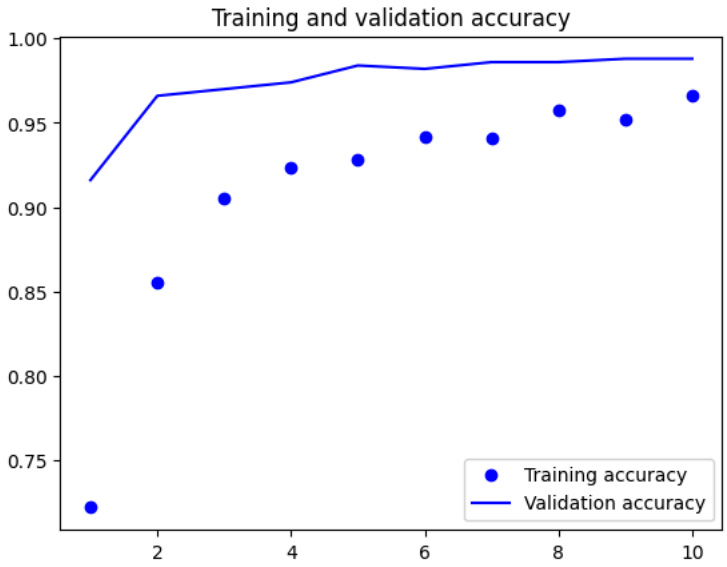
```
data_augmentation = keras.Sequential(
    [
        layers.RandomFlip("horizontal"),
        layers.RandomRotation(0.1),
        layers.RandomZoom(0.2),
    ]
)
```

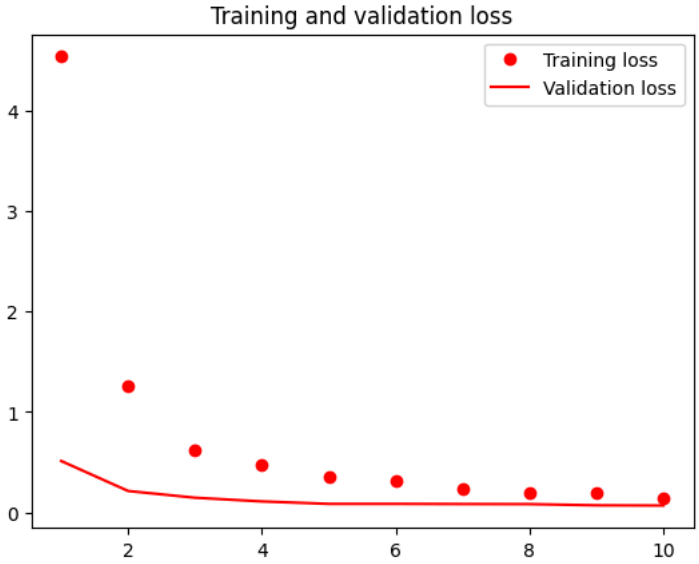
```
inputs = keras.Input(shape=(180, 180, 3))
x = data_augmentation(inputs)
```

```
x = keras.applications.vgg16.preprocess_input(x)
x = conv_base(x)
x = layers.Flatten()(x)
x = layers.Dense(256)(x)
x = layers.Dropout(0.5)(x)
outputs = layers.Dense(1, activation="sigmoid")(x)
model = keras.Model(inputs, outputs)
model.compile(loss="binary_crossentropy",
              optimizer=keras.optimizers.RMSprop(learning_rate=1e-5),
              metrics=["accuracy"])


callbacks = [
    keras.callbacks.ModelCheckpoint(
        filepath="fine_tuning3.keras",
        save_best_only=True,
        monitor="val_loss")
]
history = model.fit(
    train_dataset_4,
    epochs=10,
    validation_data=validation_dataset_4,
    callbacks=callbacks)
```

```
Epoch 1/10
54/54 ━━━━━━━━━━━━━━━━━━━━ 62s 1s/step - accuracy: 0.6422 - loss: 6.8720 - val_accuracy: 0.9160 - val_loss: 0.5122
Epoch 2/10
54/54 ━━━━━━━━━━━━━━━━━━━━ 32s 170ms/step - accuracy: 0.8464 - loss: 1.3208 - val_accuracy: 0.9660 - val_loss: 0.2141
Epoch 3/10
54/54 ━━━━━━━━━━━━━━━━━━━━ 10s 157ms/step - accuracy: 0.9149 - loss: 0.5365 - val_accuracy: 0.9700 - val_loss: 0.1471
Epoch 4/10
54/54 ━━━━━━━━━━━━━━━━━━━━ 11s 189ms/step - accuracy: 0.9198 - loss: 0.4791 - val_accuracy: 0.9740 - val_loss: 0.1103
Epoch 5/10
54/54 ━━━━━━━━━━━━━━━━━━━━ 19s 173ms/step - accuracy: 0.9230 - loss: 0.3690 - val_accuracy: 0.9840 - val_loss: 0.0859
Epoch 6/10
54/54 ━━━━━━━━━━━━━━━━━━━━ 8s 151ms/step - accuracy: 0.9363 - loss: 0.2982 - val_accuracy: 0.9820 - val_loss: 0.0860
Epoch 7/10
54/54 ━━━━━━━━━━━━━━━━━━━━ 12s 190ms/step - accuracy: 0.9461 - loss: 0.2176 - val_accuracy: 0.9860 - val_loss: 0.0844
Epoch 8/10
54/54 ━━━━━━━━━━━━━━━━━━━━ 11s 196ms/step - accuracy: 0.9510 - loss: 0.2066 - val_accuracy: 0.9860 - val_loss: 0.0835
Epoch 9/10
54/54 ━━━━━━━━━━━━━━━━━━━━ 19s 173ms/step - accuracy: 0.9442 - loss: 0.2365 - val_accuracy: 0.9880 - val_loss: 0.0717
Epoch 10/10
54/54 ━━━━━━━━━━━━━━━━━━━━ 10s 190ms/step - accuracy: 0.9657 - loss: 0.1672 - val_accuracy: 0.9880 - val_loss: 0.0696
```

```
import matplotlib.pyplot as plt
accuracy = history.history["accuracy"]
val_accuracy = history.history["val_accuracy"]
loss = history.history["loss"]
val_loss = history.history["val_loss"]
epochs = range(1, len(accuracy) + 1)
plt.plot(epochs, accuracy, "bo", label="Training accuracy")
plt.plot(epochs, val_accuracy, "b", label="Validation accuracy")
plt.title("Training and validation accuracy")
plt.legend()
plt.figure()
plt.plot(epochs, loss, "ro", label="Training loss")
plt.plot(epochs, val_loss, "r", label="Validation loss")
plt.title("Training and validation loss")
plt.legend()
plt.show()
```






```
model = keras.models.load_model("fine_tuning3.keras")
test_loss, test_acc = model.evaluate(test_dataset)
print(f"Test accuracy: {test_acc:.3f}")
```

```
19/19 ━━━━━━━━━━━━━━━━━━━━ 3s 125ms/step - accuracy: 0.9616 - loss: 0.2552
Test accuracy: 0.965
```

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