Assignment-2

*Convolution *

** Uploading the data**

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

```
Mounted at /content/drive
```

Transferring images into training, validation, and testing folders

```
import os
import shutil
import pathlib

# Define original folders separately
source_train_dir = pathlib.Path("/content/drive/MyDrive/cats_vs_dogs_small/train")
source_validation_dir = pathlib.Path("/content/drive/MyDrive/cats_vs_dogs_small/validation")
source_test_dir = pathlib.Path("/content/drive/MyDrive/cats_vs_dogs_small/test")

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

def create_dataset_subset(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 = target_dataset_dir / subset_name / category

        os.makedirs(dest_dir, exist_ok=True)

        files = sorted(os.listdir(src_dir))


        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():



    create_dataset_subset("train", source_train_dir, 0, 500)
    create_dataset_subset("validation", source_validation_dir, 0, 250)
    create_dataset_subset("test",   source_test_dir, 0, 250)

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

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

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

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

```
create_dataset_subset("train", source_train_dir, 0, 500)
create_dataset_subset("validation", source_validation_dir, 0, 250)
create_dataset_subset("test",   source_test_dir, 0, 250)
```

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

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

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

```
from tensorflow.keras.utils import image_dataset_from_directory

train_ds = image_dataset_from_directory(
    target_dataset_dir / "train",
    image_size=(180, 180),
    batch_size=32
)

val_ds = image_dataset_from_directory(
    target_dataset_dir / "validation",
    image_size=(180, 180),
    batch_size=32
)

test_ds = image_dataset_from_directory(
    target_dataset_dir / "test",
    image_size=(180, 180),
    batch_size=32
)
```

```
Found 1000 files belonging to 2 classes.
Found 500 files belonging to 2 classes.
Found 500 files belonging to 2 classes.
```

Training a convent neural network from the beginning

Model 1:The dataset consists of 1000 samples for training, 500 for validation, and 500 for testing.

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

Building a simple ConvNet to distinguish between dogs and cats.

```
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()
```

Model: "functional"

Layer (type)	Output Shape	Param #
input_layer (InputLayer)	(None, 180, 180, 3)	0
rescaling (Rescaling)	(None, 180, 180, 3)	0
conv2d (Conv2D)	(None, 178, 178, 32)	896
max_pooling2d (MaxPooling2D)	(None, 89, 89, 32)	0
conv2d_1 (Conv2D)	(None, 87, 87, 64)	18,496
max_pooling2d_1 (MaxPooling2D)	(None, 43, 43, 64)	0
conv2d_2 (Conv2D)	(None, 41, 41, 128)	73,856
max_pooling2d_2 (MaxPooling2D)	(None, 20, 20, 128)	0
conv2d_3 (Conv2D)	(None, 18, 18, 256)	295,168
max_pooling2d_3 (MaxPooling2D)	(None, 9, 9, 256)	0
conv2d_4 (Conv2D)	(None, 7, 7, 256)	590,080
flatten (Flatten)	(None, 12544)	0
dense (Dense)	(None, 1)	12,545

Total params: 991,041 (3.78 MB)
Trainable params: 991,041 (3.78 MB)
Non-trainable params: 0 (0.00 B)

Setting up the model for training

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

Data preparation

```
from tensorflow.keras.utils import image_dataset_from_directory

# Base directory for the subsets
balanced_subset_dir = pathlib.Path("/content/drive/MyDrive/cats_vs_dogs_small/small_dataset_balanced")

# Load datasets
train_ds = image_dataset_from_directory(
    balanced_subset_dir / "train",
    image_size=(180, 180),
    batch_size=32
)

val_ds = image_dataset_from_directory(
    balanced_subset_dir / "validation",
    image_size=(180, 180),
    batch_size=32
)

test_ds = image_dataset_from_directory(
    balanced_subset_dir / "test",
    image_size=(180, 180),
    batch_size=32
)
```

```
Found 1000 files belonging to 2 classes.
Found 500 files belonging to 2 classes.
Found 500 files belonging to 2 classes.
```

```
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
```

```
(16,)
(16,)
(16,)
```

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

```
(32, 16)
(32, 16)
(32, 16)
```

```
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
```

```
(4, 4)
(4, 4)
(4, 4)
```

Showing the dimensions of the data and labels returned by the Dataset

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

```
data batch shape: (32, 180, 180, 3)
labels batch shape: (32,)
```

Training the model with a dataset

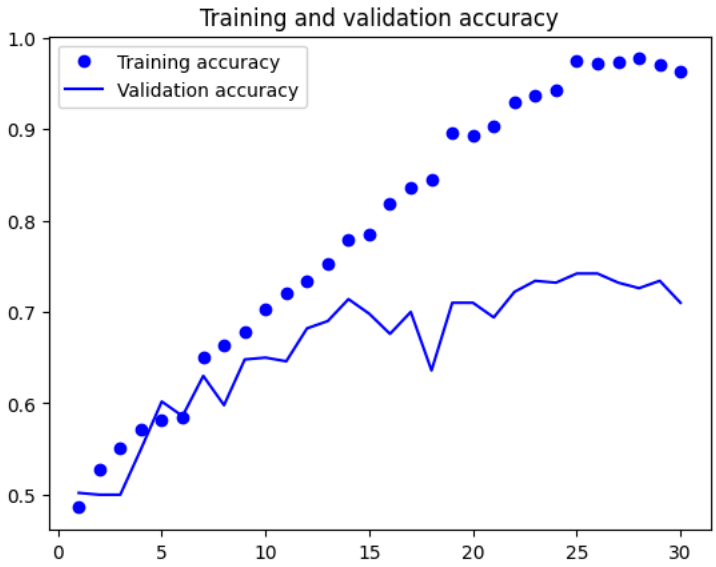
```
callbacks = [
    keras.callbacks.ModelCheckpoint(
        filepath="convnet_from_scratch.keras",
        save_best_only=True,
        monitor="val_loss")
]
history = model.fit(
    train_ds,
    epochs=30,
    validation_data=val_ds,
    callbacks=callbacks)
```

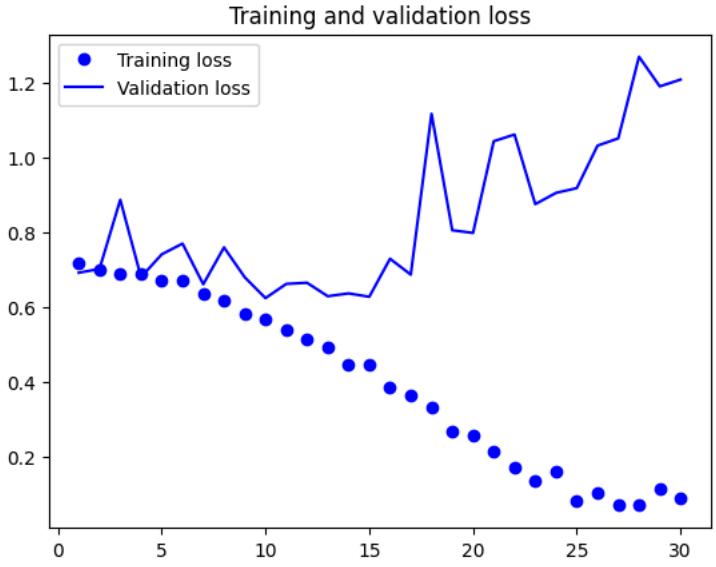
```
Epoch 1/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 16s 309ms/step - accuracy: 0.4607 - loss: 0.7651 - val_accuracy: 0.5020 - val_loss: 0.6917
Epoch 2/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 11s 182ms/step - accuracy: 0.5038 - loss: 0.6964 - val_accuracy: 0.5000 - val_loss: 0.7021
Epoch 3/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 11s 204ms/step - accuracy: 0.5436 - loss: 0.6923 - val_accuracy: 0.5000 - val_loss: 0.8871
Epoch 4/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 184ms/step - accuracy: 0.5528 - loss: 0.7245 - val_accuracy: 0.5500 - val_loss: 0.6801
Epoch 5/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 10s 182ms/step - accuracy: 0.5543 - loss: 0.6774 - val_accuracy: 0.6020 - val_loss: 0.7410
Epoch 6/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 10s 183ms/step - accuracy: 0.5525 - loss: 0.6972 - val_accuracy: 0.5860 - val_loss: 0.7698
Epoch 7/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 10s 177ms/step - accuracy: 0.6323 - loss: 0.6582 - val_accuracy: 0.6300 - val_loss: 0.6608
Epoch 8/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 10s 187ms/step - accuracy: 0.6423 - loss: 0.6288 - val_accuracy: 0.5980 - val_loss: 0.7596
Epoch 9/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 188ms/step - accuracy: 0.6656 - loss: 0.5885 - val_accuracy: 0.6480 - val_loss: 0.6795
Epoch 10/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 11s 203ms/step - accuracy: 0.6988 - loss: 0.5713 - val_accuracy: 0.6500 - val_loss: 0.6238
Epoch 11/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 183ms/step - accuracy: 0.7000 - loss: 0.5378 - val_accuracy: 0.6460 - val_loss: 0.6618
Epoch 12/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 9s 153ms/step - accuracy: 0.7137 - loss: 0.5255 - val_accuracy: 0.6820 - val_loss: 0.6649
Epoch 13/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 188ms/step - accuracy: 0.7402 - loss: 0.4898 - val_accuracy: 0.6900 - val_loss: 0.6288
Epoch 14/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 9s 146ms/step - accuracy: 0.7799 - loss: 0.4510 - val_accuracy: 0.7140 - val_loss: 0.6365
Epoch 15/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 7s 222ms/step - accuracy: 0.7760 - loss: 0.4689 - val_accuracy: 0.6980 - val_loss: 0.6273
Epoch 16/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 9s 188ms/step - accuracy: 0.8183 - loss: 0.3982 - val_accuracy: 0.6760 - val_loss: 0.7291
Epoch 17/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 10s 188ms/step - accuracy: 0.8180 - loss: 0.4011 - val_accuracy: 0.7000 - val_loss: 0.6867
```

```
Epoch 18/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 7s 218ms/step - accuracy: 0.8374 - loss: 0.3272 - val_accuracy: 0.6360 - val_loss: 1.1173
Epoch 19/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 9s 183ms/step - accuracy: 0.8714 - loss: 0.3248 - val_accuracy: 0.7100 - val_loss: 0.8055
Epoch 20/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 191ms/step - accuracy: 0.8828 - loss: 0.2814 - val_accuracy: 0.7100 - val_loss: 0.7983
Epoch 21/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 10s 187ms/step - accuracy: 0.8796 - loss: 0.2720 - val_accuracy: 0.6940 - val_loss: 1.0440
Epoch 22/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 5s 148ms/step - accuracy: 0.9369 - loss: 0.1726 - val_accuracy: 0.7220 - val_loss: 1.0618
Epoch 23/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 178ms/step - accuracy: 0.9388 - loss: 0.1440 - val_accuracy: 0.7340 - val_loss: 0.8754
Epoch 24/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 185ms/step - accuracy: 0.9547 - loss: 0.1362 - val_accuracy: 0.7320 - val_loss: 0.9056
Epoch 25/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 180ms/step - accuracy: 0.9747 - loss: 0.0762 - val_accuracy: 0.7420 - val_loss: 0.9183
Epoch 26/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 5s 166ms/step - accuracy: 0.9702 - loss: 0.1141 - val_accuracy: 0.7420 - val_loss: 1.0321
Epoch 27/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 11s 179ms/step - accuracy: 0.9813 - loss: 0.0508 - val_accuracy: 0.7320 - val_loss: 1.0516
Epoch 28/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 5s 152ms/step - accuracy: 0.9713 - loss: 0.0826 - val_accuracy: 0.7260 - val_loss: 1.2701
Epoch 29/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 5s 157ms/step - accuracy: 0.9774 - loss: 0.0862 - val_accuracy: 0.7340 - val_loss: 1.1908
```

Visualizing the loss and accuracy trends throughout 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()
```





Assessing the model's performance on the test set

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

```
16/16 ━━━━━━━━━━━━━━━━━━━━ 3s 139ms/step - accuracy: 0.6020 - loss: 0.6741
Test accuracy: 0.608
```

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: Applying 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_ds,
    epochs=30,
    validation_data=val_ds,
     callbacks=callbacks)
```

```
Epoch 1/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 11s 227ms/step - accuracy: 0.4829 - loss: 0.6984 - val_accuracy: 0.5000 - val_loss: 0.7005
Epoch 2/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 181ms/step - accuracy: 0.5042 - loss: 0.6965 - val_accuracy: 0.5000 - val_loss: 0.8050
Epoch 3/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 196ms/step - accuracy: 0.5372 - loss: 0.6985 - val_accuracy: 0.6000 - val_loss: 0.6774
Epoch 4/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 180ms/step - accuracy: 0.5754 - loss: 0.6863 - val_accuracy: 0.5020 - val_loss: 0.6856
Epoch 5/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 10s 157ms/step - accuracy: 0.5655 - loss: 0.6862 - val_accuracy: 0.5660 - val_loss: 0.6853
Epoch 6/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 5s 151ms/step - accuracy: 0.5898 - loss: 0.6753 - val_accuracy: 0.5000 - val_loss: 1.1144
Epoch 7/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 7s 220ms/step - accuracy: 0.5984 - loss: 0.6854 - val_accuracy: 0.6520 - val_loss: 0.6308
Epoch 8/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 9s 177ms/step - accuracy: 0.6298 - loss: 0.6545 - val_accuracy: 0.5140 - val_loss: 0.7281
Epoch 9/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 9s 140ms/step - accuracy: 0.6641 - loss: 0.6179 - val_accuracy: 0.5080 - val_loss: 1.1961
Epoch 10/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 183ms/step - accuracy: 0.6456 - loss: 0.7072 - val_accuracy: 0.6500 - val_loss: 0.6105
Epoch 11/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 178ms/step - accuracy: 0.6977 - loss: 0.5841 - val_accuracy: 0.5440 - val_loss: 0.7247
Epoch 12/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 180ms/step - accuracy: 0.6479 - loss: 0.6317 - val_accuracy: 0.6500 - val_loss: 0.6274
Epoch 13/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 9s 147ms/step - accuracy: 0.6718 - loss: 0.6008 - val_accuracy: 0.6200 - val_loss: 0.6521
Epoch 14/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 7s 213ms/step - accuracy: 0.6885 - loss: 0.5956 - val_accuracy: 0.6940 - val_loss: 0.5890
Epoch 15/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 9s 178ms/step - accuracy: 0.6954 - loss: 0.5901 - val_accuracy: 0.6180 - val_loss: 0.7597
Epoch 16/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 9s 143ms/step - accuracy: 0.6994 - loss: 0.5756 - val_accuracy: 0.7100 - val_loss: 0.5524
Epoch 17/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 7s 211ms/step - accuracy: 0.7282 - loss: 0.5613 - val_accuracy: 0.6760 - val_loss: 0.6054
Epoch 18/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 5s 141ms/step - accuracy: 0.6929 - loss: 0.6061 - val_accuracy: 0.7020 - val_loss: 0.5674
Epoch 19/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 5s 162ms/step - accuracy: 0.7370 - loss: 0.5281 - val_accuracy: 0.6000 - val_loss: 0.8617
Epoch 20/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 11s 179ms/step - accuracy: 0.7318 - loss: 0.5856 - val_accuracy: 0.7220 - val_loss: 0.5306
Epoch 21/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 7s 214ms/step - accuracy: 0.7323 - loss: 0.5450 - val_accuracy: 0.7160 - val_loss: 0.5529
Epoch 22/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 177ms/step - accuracy: 0.7743 - loss: 0.5131 - val_accuracy: 0.7020 - val_loss: 0.5753
Epoch 23/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 10s 177ms/step - accuracy: 0.7537 - loss: 0.5165 - val_accuracy: 0.7040 - val_loss: 0.6327
Epoch 24/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 10s 180ms/step - accuracy: 0.7584 - loss: 0.5203 - val_accuracy: 0.6840 - val_loss: 0.7408
Epoch 25/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 182ms/step - accuracy: 0.7478 - loss: 0.5532 - val_accuracy: 0.6860 - val_loss: 0.6610
Epoch 26/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 9s 149ms/step - accuracy: 0.7576 - loss: 0.5022 - val_accuracy: 0.7540 - val_loss: 0.5232
Epoch 27/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 182ms/step - accuracy: 0.7753 - loss: 0.4707 - val_accuracy: 0.7300 - val_loss: 0.7040
Epoch 28/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 9s 144ms/step - accuracy: 0.7831 - loss: 0.4740 - val_accuracy: 0.7340 - val_loss: 0.6189
Epoch 29/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 7s 217ms/step - accuracy: 0.7696 - loss: 0.4685 - val_accuracy: 0.7220 - val_loss: 0.6213
```

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

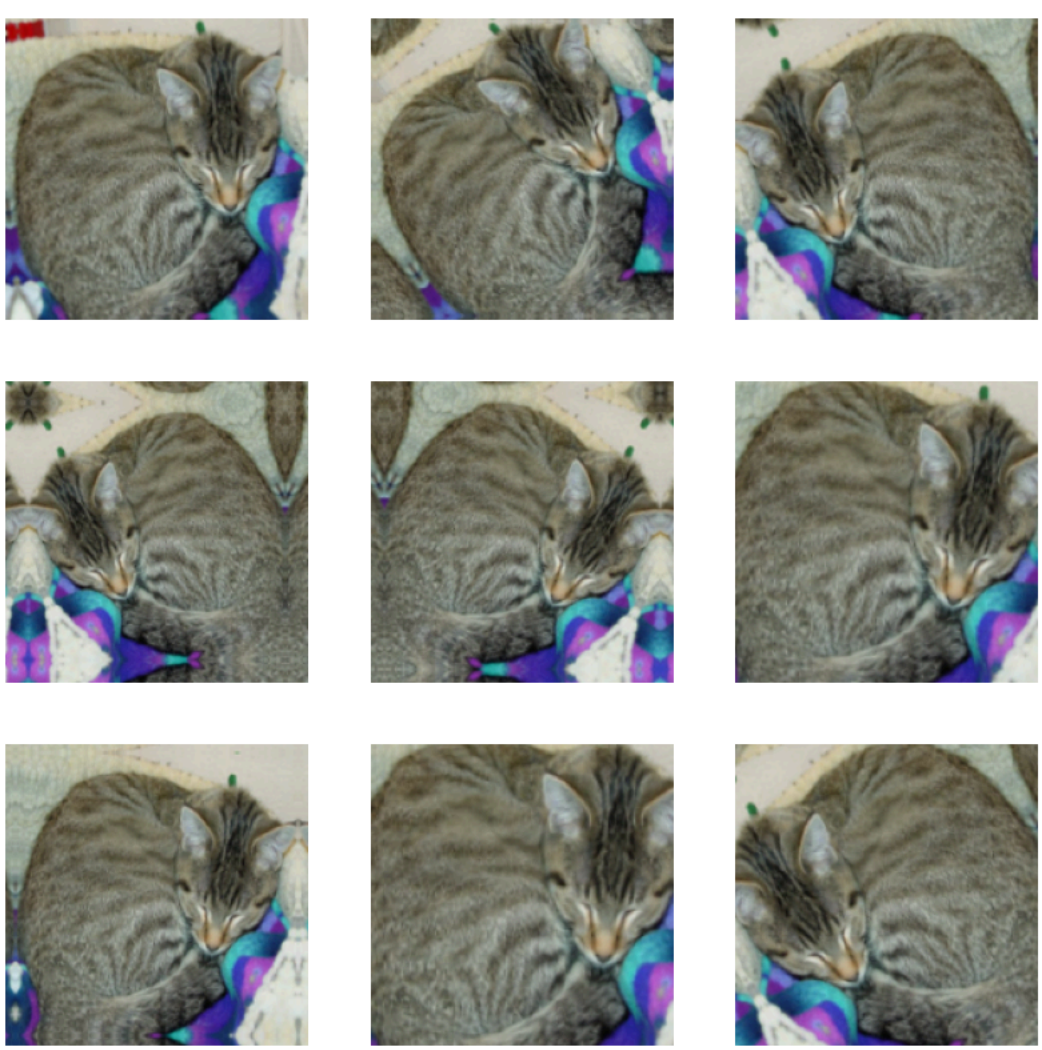
```
16/16 ━━━━━━━━━━━━━━━━━━━━ 2s 90ms/step - accuracy: 0.7121 - loss: 0.5589
Test accuracy: 0.720
```

Creating a data augmentation step for an image model

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

Showing a selection of randomly augmented training images

```
plt.figure(figsize=(10, 10))
for images, _ in train_ds.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: Applying the Dropout Technique

```
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_ds,
    epochs=30,
    validation_data=val_ds,
    callbacks=callbacks)
```

```
Epoch 1/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 11s 246ms/step - accuracy: 0.4900 - loss: 0.7026 - val_accuracy: 0.5000 - val_loss: 0.6925
Epoch 2/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 5s 141ms/step - accuracy: 0.5098 - loss: 0.6926 - val_accuracy: 0.5320 - val_loss: 0.6911
Epoch 3/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 182ms/step - accuracy: 0.5546 - loss: 0.7005 - val_accuracy: 0.5000 - val_loss: 2.7615
Epoch 4/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 185ms/step - accuracy: 0.5684 - loss: 0.9235 - val_accuracy: 0.6140 - val_loss: 0.6525
Epoch 5/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 5s 147ms/step - accuracy: 0.5729 - loss: 0.6785 - val_accuracy: 0.5040 - val_loss: 0.7390
Epoch 6/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 167ms/step - accuracy: 0.5996 - loss: 0.6562 - val_accuracy: 0.5060 - val_loss: 0.9531
Epoch 7/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 5s 143ms/step - accuracy: 0.5937 - loss: 0.7093 - val_accuracy: 0.6200 - val_loss: 0.6487
Epoch 8/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 183ms/step - accuracy: 0.6725 - loss: 0.6189 - val_accuracy: 0.6340 - val_loss: 0.6186
Epoch 9/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 180ms/step - accuracy: 0.6776 - loss: 0.6023 - val_accuracy: 0.6580 - val_loss: 0.6204
Epoch 10/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 10s 164ms/step - accuracy: 0.6771 - loss: 0.6063 - val_accuracy: 0.6620 - val_loss: 0.6364
Epoch 11/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 5s 142ms/step - accuracy: 0.6984 - loss: 0.5843 - val_accuracy: 0.6800 - val_loss: 0.5910
Epoch 12/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 176ms/step - accuracy: 0.6931 - loss: 0.5553 - val_accuracy: 0.6740 - val_loss: 0.5981
Epoch 13/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 176ms/step - accuracy: 0.7194 - loss: 0.5433 - val_accuracy: 0.6360 - val_loss: 0.7535
Epoch 14/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 4s 138ms/step - accuracy: 0.7933 - loss: 0.4825 - val_accuracy: 0.6340 - val_loss: 0.8202
Epoch 15/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 175ms/step - accuracy: 0.7426 - loss: 0.5536 - val_accuracy: 0.6840 - val_loss: 0.5818
Epoch 16/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 10s 179ms/step - accuracy: 0.7683 - loss: 0.4677 - val_accuracy: 0.6960 - val_loss: 0.5767
Epoch 17/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 10s 178ms/step - accuracy: 0.8128 - loss: 0.3979 - val_accuracy: 0.6800 - val_loss: 0.7149
Epoch 18/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 9s 141ms/step - accuracy: 0.8134 - loss: 0.3984 - val_accuracy: 0.7340 - val_loss: 0.5816
Epoch 19/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 178ms/step - accuracy: 0.8452 - loss: 0.3639 - val_accuracy: 0.7160 - val_loss: 0.7291
Epoch 20/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 10s 175ms/step - accuracy: 0.8395 - loss: 0.3536 - val_accuracy: 0.6960 - val_loss: 0.6361
Epoch 21/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 9s 140ms/step - accuracy: 0.8602 - loss: 0.3057 - val_accuracy: 0.7120 - val_loss: 0.6471
Epoch 22/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 176ms/step - accuracy: 0.8795 - loss: 0.2729 - val_accuracy: 0.7060 - val_loss: 0.5993
Epoch 23/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 177ms/step - accuracy: 0.8907 - loss: 0.2451 - val_accuracy: 0.7400 - val_loss: 0.6909
Epoch 24/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 10s 174ms/step - accuracy: 0.9221 - loss: 0.1946 - val_accuracy: 0.7360 - val_loss: 0.7292
Epoch 25/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 4s 139ms/step - accuracy: 0.9353 - loss: 0.1626 - val_accuracy: 0.6460 - val_loss: 1.3702
Epoch 26/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 174ms/step - accuracy: 0.9167 - loss: 0.1838 - val_accuracy: 0.7460 - val_loss: 0.7082
Epoch 27/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 183ms/step - accuracy: 0.9602 - loss: 0.1348 - val_accuracy: 0.7480 - val_loss: 0.7764
Epoch 28/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 174ms/step - accuracy: 0.9502 - loss: 0.1248 - val_accuracy: 0.7360 - val_loss: 1.0705
Epoch 29/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 202ms/step - accuracy: 0.9595 - loss: 0.1094 - val_accuracy: 0.7340 - val_loss: 1.0496
```

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

```
16/16 ━━━━━━━━━━━━━━━━━━━━ 2s 90ms/step - accuracy: 0.7166 - loss: 0.5733
Test accuracy: 0.702
```

Model 1c: Applying both Image Augmentation and Dropout techniques

```
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_ds,
    epochs=30,
    validation_data=val_ds,
    callbacks=callbacks)
```

```
Epoch 1/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 8s 188ms/step - accuracy: 0.4749 - loss: 0.7409 - val_accuracy: 0.5000 - val_loss: 0.6917
Epoch 2/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 11s 204ms/step - accuracy: 0.5095 - loss: 0.6943 - val_accuracy: 0.5000 - val_loss: 0.6917
Epoch 3/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 10s 200ms/step - accuracy: 0.5360 - loss: 0.6913 - val_accuracy: 0.5000 - val_loss: 0.7703
Epoch 4/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 10s 184ms/step - accuracy: 0.5129 - loss: 0.7007 - val_accuracy: 0.5300 - val_loss: 0.6899
Epoch 5/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 9s 147ms/step - accuracy: 0.5501 - loss: 0.6877 - val_accuracy: 0.5920 - val_loss: 0.6728
Epoch 6/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 7s 202ms/step - accuracy: 0.5994 - loss: 0.6742 - val_accuracy: 0.6080 - val_loss: 0.6679
Epoch 7/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 5s 143ms/step - accuracy: 0.6253 - loss: 0.6538 - val_accuracy: 0.5140 - val_loss: 0.6824
Epoch 8/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 5s 157ms/step - accuracy: 0.6019 - loss: 0.6607 - val_accuracy: 0.6000 - val_loss: 0.6549
Epoch 9/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 169ms/step - accuracy: 0.6635 - loss: 0.6358 - val_accuracy: 0.6660 - val_loss: 0.6274
Epoch 10/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 5s 144ms/step - accuracy: 0.6491 - loss: 0.6604 - val_accuracy: 0.6500 - val_loss: 0.6237
Epoch 11/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 7s 199ms/step - accuracy: 0.6235 - loss: 0.6289 - val_accuracy: 0.5400 - val_loss: 1.1512
Epoch 12/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 9s 145ms/step - accuracy: 0.6455 - loss: 0.6645 - val_accuracy: 0.6680 - val_loss: 0.6206
Epoch 13/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 7s 217ms/step - accuracy: 0.6509 - loss: 0.6060 - val_accuracy: 0.6320 - val_loss: 0.6318
Epoch 14/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 9s 167ms/step - accuracy: 0.7051 - loss: 0.5723 - val_accuracy: 0.7320 - val_loss: 0.5628
Epoch 15/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 5s 165ms/step - accuracy: 0.7170 - loss: 0.5479 - val_accuracy: 0.6160 - val_loss: 0.7264
Epoch 16/30
```

```
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 182ms/step - accuracy: 0.6857 - loss: 0.6132 - val_accuracy: 0.6940 - val_loss: 0.5701
Epoch 17/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 7s 221ms/step - accuracy: 0.7105 - loss: 0.5672 - val_accuracy: 0.7220 - val_loss: 0.5603
Epoch 18/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 189ms/step - accuracy: 0.7426 - loss: 0.5301 - val_accuracy: 0.7280 - val_loss: 0.5577
Epoch 19/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 9s 152ms/step - accuracy: 0.7082 - loss: 0.5574 - val_accuracy: 0.6300 - val_loss: 0.6141
Epoch 20/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 182ms/step - accuracy: 0.7229 - loss: 0.5492 - val_accuracy: 0.6920 - val_loss: 0.5894
Epoch 21/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 191ms/step - accuracy: 0.7486 - loss: 0.5334 - val_accuracy: 0.6900 - val_loss: 0.5905
Epoch 22/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 181ms/step - accuracy: 0.7140 - loss: 0.5483 - val_accuracy: 0.7180 - val_loss: 0.5731
Epoch 23/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 10s 180ms/step - accuracy: 0.7489 - loss: 0.5130 - val_accuracy: 0.7400 - val_loss: 0.6040
Epoch 24/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 10s 180ms/step - accuracy: 0.7326 - loss: 0.5161 - val_accuracy: 0.7360 - val_loss: 0.5756
Epoch 25/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 10s 177ms/step - accuracy: 0.7813 - loss: 0.4760 - val_accuracy: 0.6920 - val_loss: 0.7286
Epoch 26/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 6s 182ms/step - accuracy: 0.7636 - loss: 0.5264 - val_accuracy: 0.7580 - val_loss: 0.5162
Epoch 27/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 5s 166ms/step - accuracy: 0.7686 - loss: 0.4866 - val_accuracy: 0.7280 - val_loss: 0.5587
Epoch 28/30
32/32 ━━━━━━━━━━━━━━━━━━━━ 12s 215ms/step - accuracy: 0.7630 - loss: 0.4742 - val_accuracy: 0.7580 - val_loss: 0.5101
Epoch 29/30
```

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

```
16/16 ━━━━━━━━━━━━━━━━━━━━ 2s 92ms/step - accuracy: 0.7054 - loss: 0.5452
Test accuracy: 0.718
```

Model 2) Increased the training sample size to 1500 while incorporating MaxPooling, Data Augmentation, and applying Dropout regularization with a rate of 0.5.

```
import os
import shutil
import pathlib

# Define original folders (your dataset path)
source_train_dir = pathlib.Path("/content/drive/MyDrive/cats_vs_dogs_small/train")
source_validation_dir = pathlib.Path("/content/drive/MyDrive/cats_vs_dogs_small/validation")
source_test_dir = pathlib.Path("/content/drive/MyDrive/cats_vs_dogs_small/test")

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

def create_dataset_subset(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 = target_dataset_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():
```

```
    create_dataset_subset("train", source_train_dir, 0, 750)
    create_dataset_subset("validation", source_validation_dir, 0, 300)
    create_dataset_subset("test",   source_test_dir, 0, 300)

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

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

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

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

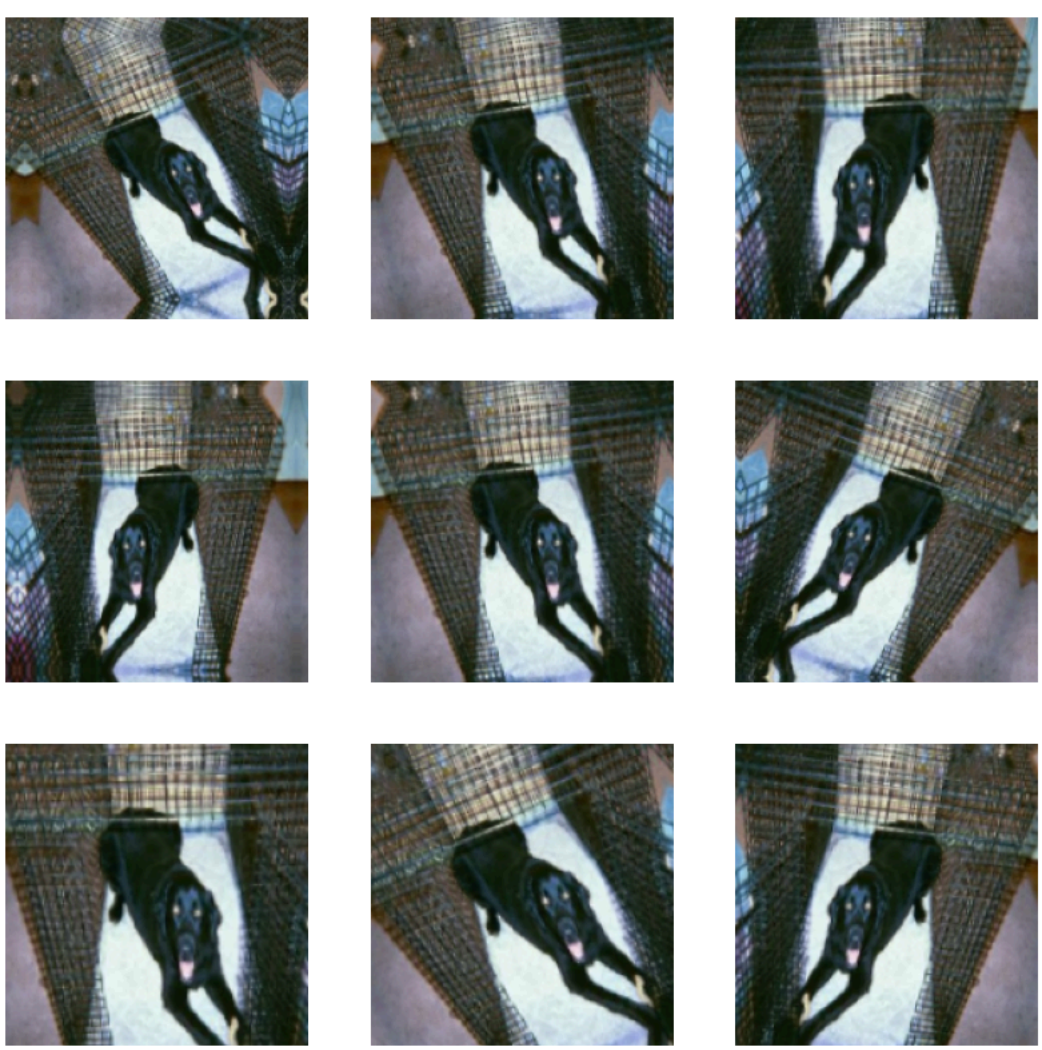
```
from tensorflow.keras.utils import image_dataset_from_directory
from pathlib import Path

target_dataset_dir = Path("/content/drive/MyDrive/cats_vs_dogs_small/cats_vs_dogs_small_subset")

train_ds = image_dataset_from_directory(
    target_dataset_dir / "train",
    image_size=(180, 180),
    batch_size=32
)

val_ds = image_dataset_from_directory(
    target_dataset_dir / "validation",
    image_size=(180, 180),
    batch_size=32
)

test_ds = image_dataset_from_directory(
    target_dataset_dir / "test",
    image_size=(180, 180),
    batch_size=32
)

# Prefetch for speed
AUTOTUNE = tf.data.AUTOTUNE
train_ds = train_ds.prefetch(buffer_size=AUTOTUNE)
val_ds = val_ds.prefetch(buffer_size=AUTOTUNE)
test_ds = test_ds.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.
```

Designing a new convolutional neural network with image augmentation and dropout layers

```
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"])
```

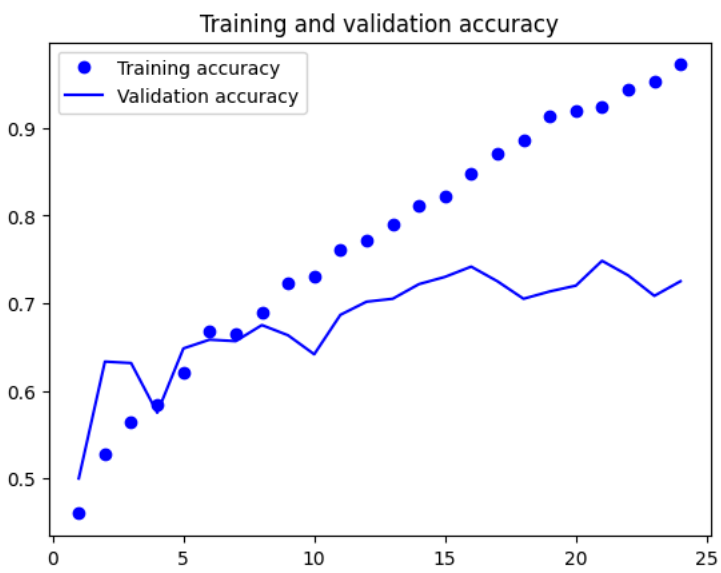
```
from tensorflow import keras
from tensorflow.keras import layers
import matplotlib.pyplot as plt
from keras.callbacks import EarlyStopping
from keras import regularizers

# 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_ds.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")
```

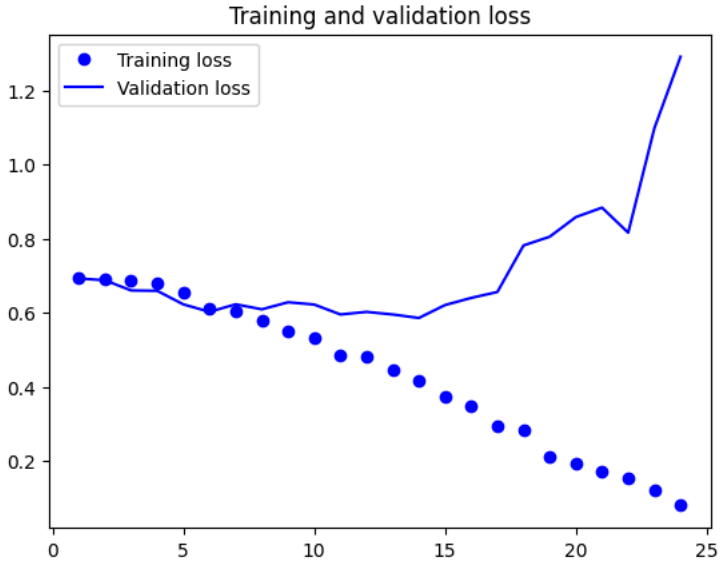


```
callbacks = [
    keras.callbacks.ModelCheckpoint(
        filepath="convnet_from_scratch.keras",
        save_best_only=True,
        monitor="val_loss"), early_stopping_monitor
]
history = model.fit(
    train_ds,
    epochs=30,
    validation_data=val_ds,
    callbacks=callbacks)
```

```
Epoch 1/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 17s 311ms/step - accuracy: 0.4481 - loss: 0.6971 - val_accuracy: 0.5000 - val_loss: 0.6928
Epoch 2/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 12s 159ms/step - accuracy: 0.5278 - loss: 0.6926 - val_accuracy: 0.6333 - val_loss: 0.6880
Epoch 3/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 8s 172ms/step - accuracy: 0.5687 - loss: 0.6919 - val_accuracy: 0.6317 - val_loss: 0.6606
Epoch 4/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 7s 159ms/step - accuracy: 0.5563 - loss: 0.6871 - val_accuracy: 0.5750 - val_loss: 0.6594
Epoch 5/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 10s 165ms/step - accuracy: 0.6050 - loss: 0.6625 - val_accuracy: 0.6483 - val_loss: 0.6229
Epoch 6/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 9s 188ms/step - accuracy: 0.6514 - loss: 0.6195 - val_accuracy: 0.6583 - val_loss: 0.6029
Epoch 7/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 12s 216ms/step - accuracy: 0.6586 - loss: 0.6131 - val_accuracy: 0.6567 - val_loss: 0.6232
Epoch 8/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 8s 160ms/step - accuracy: 0.6673 - loss: 0.6035 - val_accuracy: 0.6750 - val_loss: 0.6096
Epoch 9/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 9s 141ms/step - accuracy: 0.7127 - loss: 0.5598 - val_accuracy: 0.6633 - val_loss: 0.6286
Epoch 10/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 8s 169ms/step - accuracy: 0.6925 - loss: 0.5598 - val_accuracy: 0.6417 - val_loss: 0.6225
Epoch 11/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 10s 157ms/step - accuracy: 0.7372 - loss: 0.5072 - val_accuracy: 0.6867 - val_loss: 0.5957
Epoch 12/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 7s 157ms/step - accuracy: 0.7453 - loss: 0.5108 - val_accuracy: 0.7017 - val_loss: 0.6027
Epoch 13/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 12s 193ms/step - accuracy: 0.7832 - loss: 0.4648 - val_accuracy: 0.7050 - val_loss: 0.5957
Epoch 14/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 7s 143ms/step - accuracy: 0.7953 - loss: 0.4324 - val_accuracy: 0.7217 - val_loss: 0.5862
Epoch 15/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 11s 154ms/step - accuracy: 0.8211 - loss: 0.3829 - val_accuracy: 0.7300 - val_loss: 0.6211
Epoch 16/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 10s 154ms/step - accuracy: 0.8364 - loss: 0.3654 - val_accuracy: 0.7417 - val_loss: 0.6403
Epoch 17/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 11s 161ms/step - accuracy: 0.8563 - loss: 0.3236 - val_accuracy: 0.7250 - val_loss: 0.6563
Epoch 18/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 11s 176ms/step - accuracy: 0.8823 - loss: 0.2973 - val_accuracy: 0.7050 - val_loss: 0.7819
Epoch 19/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 9s 152ms/step - accuracy: 0.9174 - loss: 0.2193 - val_accuracy: 0.7133 - val_loss: 0.8054
Epoch 20/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 11s 160ms/step - accuracy: 0.9152 - loss: 0.2039 - val_accuracy: 0.7200 - val_loss: 0.8584
Epoch 21/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 10s 146ms/step - accuracy: 0.9053 - loss: 0.2084 - val_accuracy: 0.7483 - val_loss: 0.8839
Epoch 22/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 11s 166ms/step - accuracy: 0.9427 - loss: 0.1438 - val_accuracy: 0.7317 - val_loss: 0.8164
Epoch 23/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 7s 155ms/step - accuracy: 0.9528 - loss: 0.1191 - val_accuracy: 0.7083 - val_loss: 1.0980
Epoch 24/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 8s 176ms/step - accuracy: 0.9613 - loss: 0.1030 - val_accuracy: 0.7250 - val_loss: 1.2910
```

```
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_ds)
print(f"Test accuracy: {test_acc:.3f}")
```

```
19/19 ━━━━━━━━━━━━━━━━━━━━ 3s 85ms/step - accuracy: 0.7144 - loss: 0.6254
Test accuracy: 0.720
```

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, target_dataset_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 = target_dataset_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)

        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
source_train_dir = pathlib.Path("/content/drive/MyDrive/cats_vs_dogs_small/cats_vs_dogs_small_subset/train")
source_validation_dir = pathlib.Path("/content/drive/MyDrive/cats_vs_dogs_small/cats_vs_dogs_small_subset/validation")
source_test_dir = pathlib.Path("/content/drive/MyDrive/cats_vs_dogs_small/cats_vs_dogs_small_subset/test")

target_dataset_dir = pathlib.Path("/content/drive/MyDrive/cats_vs_dogs_small/cats_vs_dogs_small_subset")

# 3. Create Subsets
make_subset("train_4", source_train_dir, target_dataset_dir, 0, 850)
make_subset("validation_4", source_validation_dir, target_dataset_dir, 0, 250)
make_subset("test_4",   source_test_dir, target_dataset_dir, 0, 250)

# 4. Load the Subset Datasets
train_ds_4 = image_dataset_from_directory(
    target_dataset_dir / "train_4",
    image_size=(180, 180),
    batch_size=32
)

val_ds_4 = image_dataset_from_directory(
    target_dataset_dir / "validation_4",
    image_size=(180, 180),
    batch_size=32
)

test_ds_4 = image_dataset_from_directory(
    target_dataset_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(
    train_ds_4,
    epochs=30,
    validation_data=val_ds_4,
    callbacks=callbacks
)
```

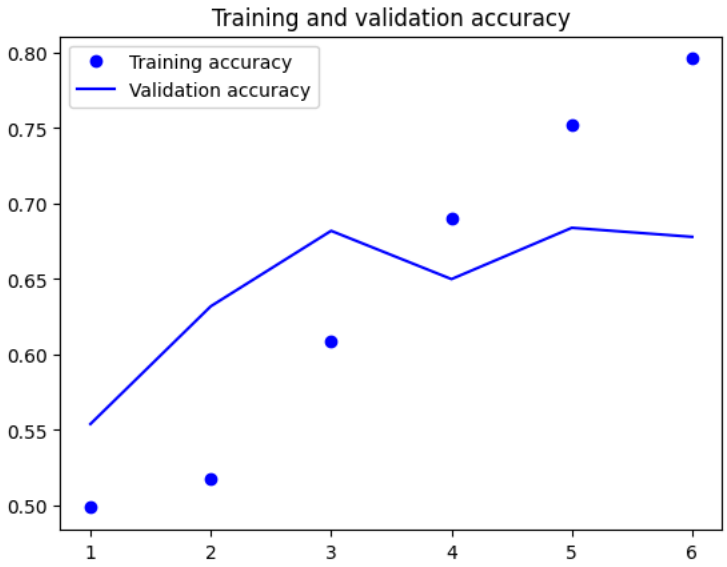
```
Creating subset: train_4 from /content/drive/MyDrive/cats_vs_dogs_small/cats_vs_dogs_small_subset/train [0:850]
 end_index 850 exceeds available files (750). Adjusting...
Copying 750 files from /content/drive/MyDrive/cats_vs_dogs_small/cats_vs_dogs_small_subset/train/cats to /content/drive/
Copying 750 files from /content/drive/MyDrive/cats_vs_dogs_small/cats_vs_dogs_small_subset/train/dogs to /content/drive/
Subset 'train_4' created successfully!

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

Creating subset: test_4 from /content/drive/MyDrive/cats_vs_dogs_small/cats_vs_dogs_small_subset/test [0:250]
Copying 250 files from /content/drive/MyDrive/cats_vs_dogs_small/cats_vs_dogs_small_subset/test/cats to /content/drive/M
Copying 250 files from /content/drive/MyDrive/cats_vs_dogs_small/cats_vs_dogs_small_subset/test/dogs to /content/drive/M
Subset 'test_4' created successfully!
Found 1500 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)
47/47 ━━━━━━━━━━━━━━━━━━━━ 27s 403ms/step - accuracy: 0.4801 - loss: 1.0577 - val_accuracy: 0.5540 - val_loss: 0.6909
Epoch 2/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 14s 309ms/step - accuracy: 0.4838 - loss: 0.6925 - val_accuracy: 0.6320 - val_loss: 0.6469
Epoch 3/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 11s 232ms/step - accuracy: 0.5761 - loss: 0.6697 - val_accuracy: 0.6820 - val_loss: 0.6006
Epoch 4/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 8s 167ms/step - accuracy: 0.6900 - loss: 0.5832 - val_accuracy: 0.6500 - val_loss: 0.6293
Epoch 5/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 10s 168ms/step - accuracy: 0.7359 - loss: 0.5216 - val_accuracy: 0.6840 - val_loss: 0.6207
Epoch 6/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 7s 146ms/step - accuracy: 0.7873 - loss: 0.4434 - val_accuracy: 0.6780 - val_loss: 0.6669
```

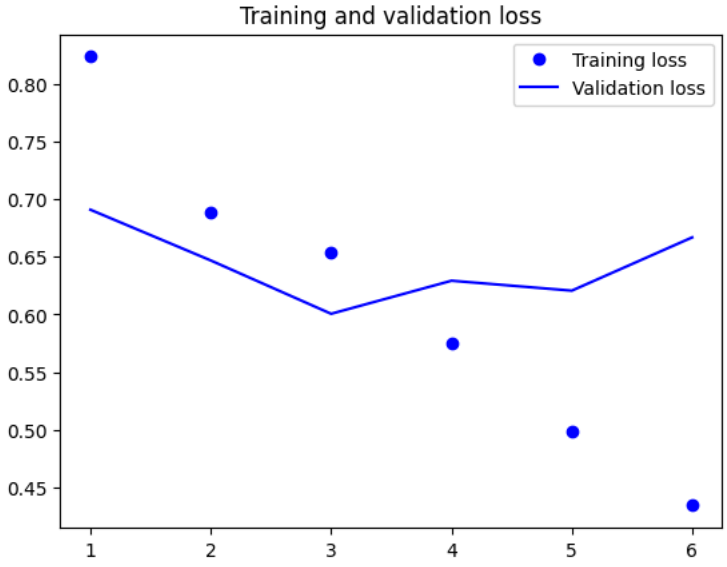
```
inputs = keras.Input(shape=(180, 180, 3))
x = data_augmentation(inputs)
x = layers.Rescaling(1./255)(inputs)
x = layers.Conv2D(filters=32, kernel_size=3, activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)
x = layers.Conv2D(filters=64, kernel_size=3, activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)
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_ds.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_ds_4)
print(f"Test accuracy: {test_acc:.3f}")
```

```
16/16 ━━━━━━━━━━━━━━━━━━━━ 3s 139ms/step - accuracy: 0.6496 - loss: 0.6409
Test accuracy: 0.642
```

Feature extraction enhanced through data augmentation

Creating and locking 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_12 (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),
    ]
)
```

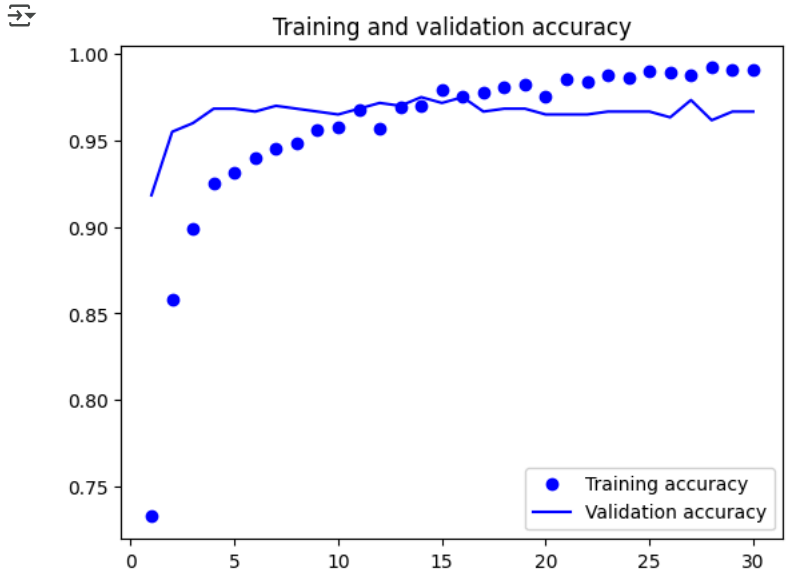
```
inputs = keras.Input(shape=(180, 180, 3))
x = data_augmentation(inputs)
x = keras.applications.vgg16.preprocess_input(x)
x = conv_base(x)
x = layers.Flatten()(x)
x = layers.Dense(256)(x)
x = layers.Dropout(0.5)(x)
outputs = layers.Dense(1, activation="sigmoid")(x)
model = keras.Model(inputs, outputs)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

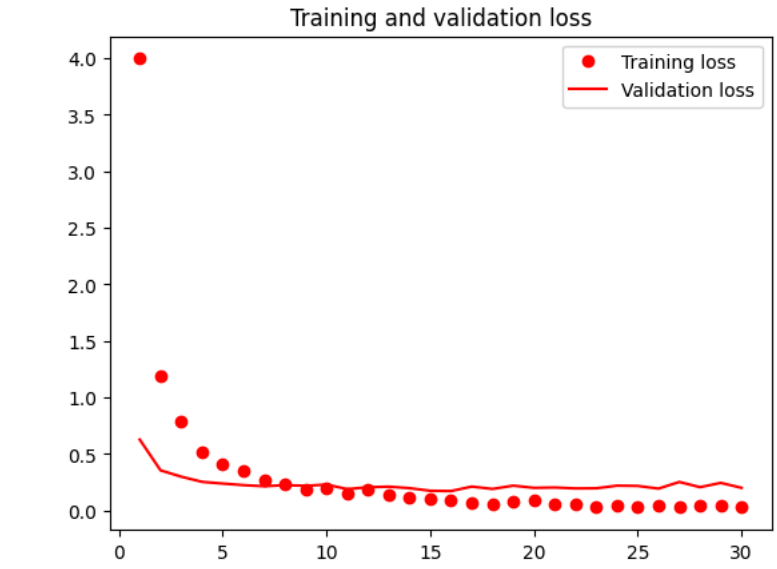
```
callbacks = [
    keras.callbacks.ModelCheckpoint(
        filepath="fine_tuning.keras",
        save_best_only=True,
        monitor="val_loss")
]
history = model.fit(
```

```
    train_ds,
    epochs=30,
    validation_data=val_ds,
    callbacks=callbacks)
```

```
Epoch 1/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 18s 269ms/step - accuracy: 0.6610 - loss: 6.2363 - val_accuracy: 0.9183 - val_loss: 0.6277
Epoch 2/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 9s 195ms/step - accuracy: 0.8583 - loss: 1.2681 - val_accuracy: 0.9550 - val_loss: 0.3561
Epoch 3/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 10s 177ms/step - accuracy: 0.8970 - loss: 0.8774 - val_accuracy: 0.9600 - val_loss: 0.2995
Epoch 4/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 11s 203ms/step - accuracy: 0.9254 - loss: 0.5290 - val_accuracy: 0.9683 - val_loss: 0.2541
Epoch 5/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 11s 201ms/step - accuracy: 0.9401 - loss: 0.3808 - val_accuracy: 0.9683 - val_loss: 0.2389
Epoch 6/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 9s 187ms/step - accuracy: 0.9404 - loss: 0.3779 - val_accuracy: 0.9667 - val_loss: 0.2249
Epoch 7/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 10s 178ms/step - accuracy: 0.9414 - loss: 0.2563 - val_accuracy: 0.9700 - val_loss: 0.2151
Epoch 8/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 9s 193ms/step - accuracy: 0.9505 - loss: 0.2225 - val_accuracy: 0.9683 - val_loss: 0.2247
Epoch 9/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 12s 225ms/step - accuracy: 0.9547 - loss: 0.1888 - val_accuracy: 0.9667 - val_loss: 0.2193
Epoch 10/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 17s 150ms/step - accuracy: 0.9625 - loss: 0.1426 - val_accuracy: 0.9650 - val_loss: 0.2300
Epoch 11/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 10s 202ms/step - accuracy: 0.9686 - loss: 0.1710 - val_accuracy: 0.9683 - val_loss: 0.1898
Epoch 12/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 9s 168ms/step - accuracy: 0.9555 - loss: 0.1784 - val_accuracy: 0.9717 - val_loss: 0.2065
Epoch 13/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 8s 160ms/step - accuracy: 0.9726 - loss: 0.1305 - val_accuracy: 0.9700 - val_loss: 0.2116
Epoch 14/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 8s 174ms/step - accuracy: 0.9701 - loss: 0.1005 - val_accuracy: 0.9750 - val_loss: 0.1982
Epoch 15/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 10s 165ms/step - accuracy: 0.9809 - loss: 0.0877 - val_accuracy: 0.9717 - val_loss: 0.1749
Epoch 16/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 9s 189ms/step - accuracy: 0.9813 - loss: 0.0618 - val_accuracy: 0.9750 - val_loss: 0.1727
Epoch 17/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 9s 181ms/step - accuracy: 0.9801 - loss: 0.0685 - val_accuracy: 0.9667 - val_loss: 0.2121
Epoch 18/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 9s 163ms/step - accuracy: 0.9816 - loss: 0.0507 - val_accuracy: 0.9683 - val_loss: 0.1913
Epoch 19/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 10s 150ms/step - accuracy: 0.9837 - loss: 0.0868 - val_accuracy: 0.9683 - val_loss: 0.2204
Epoch 20/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 9s 188ms/step - accuracy: 0.9831 - loss: 0.0911 - val_accuracy: 0.9650 - val_loss: 0.2008
Epoch 21/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 8s 164ms/step - accuracy: 0.9864 - loss: 0.0511 - val_accuracy: 0.9650 - val_loss: 0.2039
Epoch 22/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 8s 168ms/step - accuracy: 0.9873 - loss: 0.0409 - val_accuracy: 0.9650 - val_loss: 0.1959
Epoch 23/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 11s 175ms/step - accuracy: 0.9897 - loss: 0.0402 - val_accuracy: 0.9667 - val_loss: 0.1970
Epoch 24/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 8s 164ms/step - accuracy: 0.9829 - loss: 0.0527 - val_accuracy: 0.9667 - val_loss: 0.2203
Epoch 25/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 8s 165ms/step - accuracy: 0.9906 - loss: 0.0298 - val_accuracy: 0.9667 - val_loss: 0.2179
Epoch 26/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 8s 175ms/step - accuracy: 0.9921 - loss: 0.0289 - val_accuracy: 0.9633 - val_loss: 0.1941
Epoch 27/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 10s 166ms/step - accuracy: 0.9856 - loss: 0.0359 - val_accuracy: 0.9733 - val_loss: 0.2531
Epoch 28/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 10s 154ms/step - accuracy: 0.9921 - loss: 0.0540 - val_accuracy: 0.9617 - val_loss: 0.2070
Epoch 29/30
47/47 ━━━━━━━━━━━━━━━━━━━━ 11s 162ms/step - accuracy: 0.9895 - loss: 0.0429 - val_accuracy: 0.9667 - val_loss: 0.2449
```

```
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_ds)
print(f"Test accuracy: {test_acc:.3f}")
```

```
19/19 ━━━━━━━━━━━━━━━━━━━━ 3s 104ms/step - accuracy: 0.9687 - loss: 0.2743
Test accuracy: 0.970
```

Pre-Trained Model Utilizing 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_ds,
    epochs=10,
    validation_data=val_ds,
    callbacks=callbacks)
```

```
Epoch 1/10
47/47 ━━━━━━━━━━━━━━━━━━━━ 12s 204ms/step - accuracy: 0.6683 - loss: 6.3828 - val_accuracy: 0.9000 - val_loss: 0.8866
Epoch 2/10
47/47 ━━━━━━━━━━━━━━━━━━━━ 12s 243ms/step - accuracy: 0.8437 - loss: 1.4751 - val_accuracy: 0.9400 - val_loss: 0.3731
Epoch 3/10
47/47 ━━━━━━━━━━━━━━━━━━━━ 17s 182ms/step - accuracy: 0.9082 - loss: 0.8091 - val_accuracy: 0.9600 - val_loss: 0.3230
Epoch 4/10
47/47 ━━━━━━━━━━━━━━━━━━━━ 10s 202ms/step - accuracy: 0.9206 - loss: 0.7035 - val_accuracy: 0.9683 - val_loss: 0.2047
Epoch 5/10
47/47 ━━━━━━━━━━━━━━━━━━━━ 9s 176ms/step - accuracy: 0.9348 - loss: 0.4545 - val_accuracy: 0.9717 - val_loss: 0.2107
Epoch 6/10
47/47 ━━━━━━━━━━━━━━━━━━━━ 10s 180ms/step - accuracy: 0.9537 - loss: 0.2881 - val_accuracy: 0.9800 - val_loss: 0.1634
Epoch 7/10
47/47 ━━━━━━━━━━━━━━━━━━━━ 11s 195ms/step - accuracy: 0.9514 - loss: 0.2768 - val_accuracy: 0.9800 - val_loss: 0.1604
Epoch 8/10
47/47 ━━━━━━━━━━━━━━━━━━━━ 9s 185ms/step - accuracy: 0.9570 - loss: 0.2763 - val_accuracy: 0.9783 - val_loss: 0.1656
Epoch 9/10
47/47 ━━━━━━━━━━━━━━━━━━━━ 8s 161ms/step - accuracy: 0.9591 - loss: 0.2314 - val_accuracy: 0.9683 - val_loss: 0.2151
Epoch 10/10
47/47 ━━━━━━━━━━━━━━━━━━━━ 11s 176ms/step - accuracy: 0.9618 - loss: 0.1491 - val_accuracy: 0.9750 - val_loss: 0.1386
```

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

```
19/19 ━━━━━━━━━━━━━━━━━━━━ 3s 114ms/step - accuracy: 0.9713 - loss: 0.2675
Test accuracy: 0.970
```

Pre-Trained Model Utilizing 1700 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
```

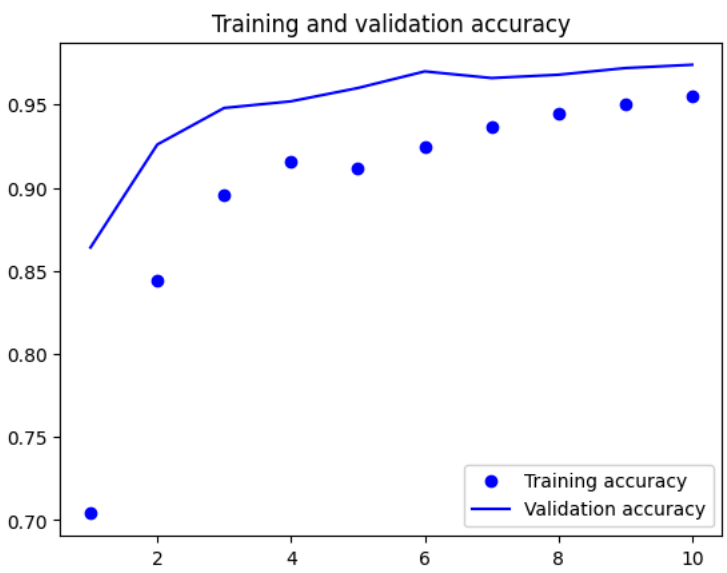
```
data_augmentation = keras.Sequential(
    [
        layers.RandomFlip("horizontal"),
        layers.RandomRotation(0.1),
        layers.RandomZoom(0.2),
    ]
)
```

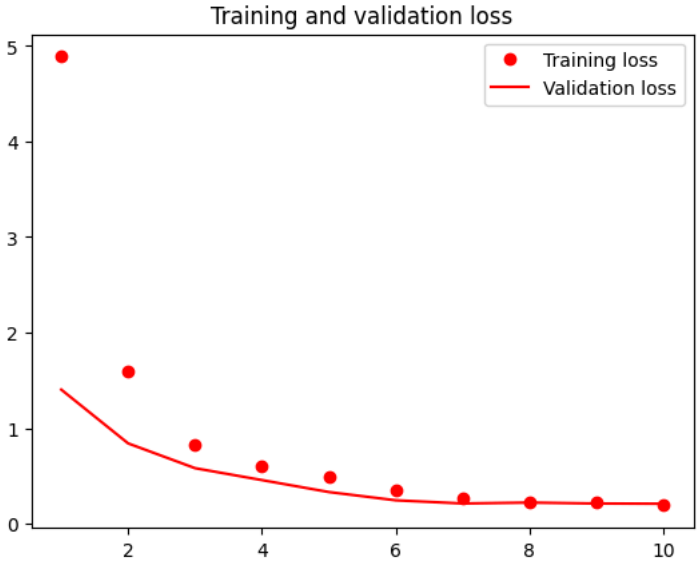
```
inputs = keras.Input(shape=(180, 180, 3))
x = data_augmentation(inputs)
```

```
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_tuning3.keras",
        save_best_only=True,
        monitor="val_loss")
]
history = model.fit(
    train_ds_4,
    epochs=10,
    validation_data=val_ds_4,
    callbacks=callbacks)
```

```
Epoch 1/10
47/47 ━━━━━━━━━━━━━━━━━━━━ 15s 264ms/step - accuracy: 0.6315 - loss: 7.2205 - val_accuracy: 0.8640 - val_loss: 1.4027
Epoch 2/10
47/47 ━━━━━━━━━━━━━━━━━━━━ 10s 196ms/step - accuracy: 0.8256 - loss: 1.8493 - val_accuracy: 0.9260 - val_loss: 0.8396
Epoch 3/10
47/47 ━━━━━━━━━━━━━━━━━━━━ 10s 196ms/step - accuracy: 0.8807 - loss: 0.9664 - val_accuracy: 0.9480 - val_loss: 0.5804
Epoch 4/10
47/47 ━━━━━━━━━━━━━━━━━━━━ 10s 209ms/step - accuracy: 0.9222 - loss: 0.5705 - val_accuracy: 0.9520 - val_loss: 0.4556
Epoch 5/10
47/47 ━━━━━━━━━━━━━━━━━━━━ 10s 206ms/step - accuracy: 0.9153 - loss: 0.4765 - val_accuracy: 0.9600 - val_loss: 0.3305
Epoch 6/10
47/47 ━━━━━━━━━━━━━━━━━━━━ 9s 193ms/step - accuracy: 0.9342 - loss: 0.3163 - val_accuracy: 0.9700 - val_loss: 0.2439
Epoch 7/10
47/47 ━━━━━━━━━━━━━━━━━━━━ 10s 191ms/step - accuracy: 0.9385 - loss: 0.2588 - val_accuracy: 0.9660 - val_loss: 0.2108
Epoch 8/10
47/47 ━━━━━━━━━━━━━━━━━━━━ 9s 192ms/step - accuracy: 0.9484 - loss: 0.1915 - val_accuracy: 0.9680 - val_loss: 0.2203
Epoch 9/10
47/47 ━━━━━━━━━━━━━━━━━━━━ 9s 194ms/step - accuracy: 0.9547 - loss: 0.2414 - val_accuracy: 0.9720 - val_loss: 0.2105
Epoch 10/10
47/47 ━━━━━━━━━━━━━━━━━━━━ 11s 203ms/step - accuracy: 0.9531 - loss: 0.2379 - val_accuracy: 0.9740 - val_loss: 0.2081
```

```
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_ds)
print(f"Test accuracy: {test_acc:.3f}")
```

```
19/19 ━━━━━━━━━━━━━━━━━━━━ 3s 130ms/step - accuracy: 0.9571 - loss: 0.2577
Test accuracy: 0.962
```

Start coding or generate with AI.

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