

# Data Augmentation

## Overview

Data augmentation is a technique used to increase the diversity of data available for training models without actually collecting new data. This technique is commonly employed in machine learning and deep learning to improve model performance and generalization.

## Importance of Data Augmentation

### 1. Improves Model Generalization

By exposing the model to various transformations of the data, it becomes more robust to variations in the real world. This helps the model to generalize better when it encounters new, unseen data.

### 2. Reduces Overfitting

Augmented data acts as a regularizer. It helps in reducing overfitting, especially when the dataset is small. Overfitting occurs when a model learns the details and noise in the training data to an extent that it negatively impacts the model's performance on new data.

### 3. Expands Dataset Size

Data augmentation artificially increases the size of the training dataset. This is particularly beneficial when collecting new data is expensive or time-consuming.

## Common Techniques

### Image Data Augmentation

#### 1. Flipping

- Horizontally or vertically flipping the images to create mirror images.

#### 2. Rotation

- Rotating images by a certain degree to make the model invariant to orientation.

#### 3. Scaling

- Scaling images up or down to simulate different zoom levels.

#### 4. Translation

- Shifting the image along the x or y axis to simulate different viewpoints.

#### 5. Cropping

- Randomly cropping a part of the image to focus on different sections.

#### 6. Color Jittering

- Changing the brightness, contrast, saturation, and hue to simulate different lighting conditions.

#### 7. Gaussian Noise

- Adding random noise to the image to make the model robust to noisy inputs.

### Text Data Augmentation

#### 1. Synonym Replacement

- Replacing words with their synonyms to create variations in the text.

#### 2. Random Insertion

- Randomly inserting words in the sentence to add variety.

#### 3. Random Swap

- Swapping words in the sentence to create new sentence structures.

#### 4. Random Deletion

- Randomly deleting words from the sentence to shorten and vary the text.

## 5. Back Translation

- Translating the sentence to another language and back to the original language to create paraphrases.

## Audio Data Augmentation

### 1. Time Stretching

- Slowing down or speeding up the audio without changing the pitch.

### 2. Pitch Shifting

- Changing the pitch of the audio without affecting the speed.

### 3. Background Noise

- Adding random noise to the audio to simulate different environments.

### 4. Random Cropping

- Cropping a random part of the audio to create shorter clips.

### 5. Volume Control

- Randomly increasing or decreasing the volume to simulate different recording levels.

## Example of Image Dataset

```
In [1]: import matplotlib.pyplot as plt
import pandas as pd
import numpy as np
import cv2
import os
import PIL
import tensorflow as tf

from tensorflow import keras
from tensorflow.keras import layers
from tensorflow.keras.models import Sequential
```

## Downloading dataset from Url

```
In [2]: dataset_url = "https://storage.googleapis.com/download.tensorflow.org/example_images/flower_photos.tgz"
tf.keras.utils.get_file('flower_photos', origin=dataset_url, cache_dir = '.',untar = True)
```

Downloading data from https://storage.googleapis.com/download.tensorflow.org/example\_images/flower\_photos.tgz  
228813984/228813984 ————— 21s 0us/step

```
Out[2]: '.\\datasets\\flower_photos'
```

```
In [2]: data_dir = '.\\datasets\\flower_photos'
```

```
In [3]: import pathlib
data_dir = pathlib.Path(data_dir) # for making a windows-path data variable
data_dir
```

```
Out[3]: WindowsPath('datasets/flower_photos')
```

## Getting total number of images in directory and their Path

```
In [4]: list(data_dir.glob('*/*.jpg'))
# for making a list all those strings in windows path (they can be subdirectory file objects) which one is given
```

```
Out[4]: [WindowsPath('datasets/flower_photos/daisy/100080576_f52e8ee070_n.jpg'),
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WindowsPath('datasets/flower_photos/dandelion/2472641499_cbe617a93d.jpg'),
WindowsPath('datasets/flower_photos/dandelion/2473862606_291ae74885.jpg'),
WindowsPath('datasets/flower_photos/dandelion/2476098674_e6f39536f5_n.jpg'),
WindowsPath('datasets/flower_photos/dandelion/2477231067_3aecef1bf8_n.jpg'),
WindowsPath('datasets/flower_photos/dandelion/2477986396_19da36d557_m.jpg'),
WindowsPath('datasets/flower_photos/dandelion/2478018280_1be353ca8c_m.jpg'),
WindowsPath('datasets/flower_photos/dandelion/2479491210_98e41c4e7d_m.jpg'),
WindowsPath('datasets/flower_photos/dandelion/2480853696_aacd5324.jpg'),
WindowsPath('datasets/flower_photos/dandelion/2481428401_bed64dd043.jpg'),
WindowsPath('datasets/flower_photos/dandelion/2489438981_4eb60ef98f_m.jpg'),
WindowsPath('datasets/flower_photos/dandelion/2490828907_5094017933_m.jpg'),
WindowsPath('datasets/flower_photos/dandelion/2494436687_775402e0aa.jpg'),
WindowsPath('datasets/flower_photos/dandelion/2495749544_679dc7cccf.jpg'),
WindowsPath('datasets/flower_photos/dandelion/2497301920_91490c42c0.jpg'),
WindowsPath('datasets/flower_photos/dandelion/2502610598_b9f1b55ebd_n.jpg'),
WindowsPath('datasets/flower_photos/dandelion/2502613166_2c231b47cb_n.jpg'),
WindowsPath('datasets/flower_photos/dandelion/2502627784_4486978bcf.jpg'),
WindowsPath('datasets/flower_photos/dandelion/2503034372_db7867de51_m.jpg'),
WindowsPath('datasets/flower_photos/dandelion/2503875867_2075a9225d_m.jpg'),
WindowsPath('datasets/flower_photos/dandelion/2512148749_261fa9d156.jpg'),
WindowsPath('datasets/flower_photos/dandelion/2512977446_ac498955ee.jpg'),
...]
```

```
In [5]: total_images = len(list(data_dir.glob('*/*.jpg')))
total_images
```

```
Out[5]: 3670
```

Selecting Specific Images of ine type of flower

```
In [6]: roses = list(data_dir.glob('roses/*'))
roses[:5]
```



```
Out[6]: [WindowsPath('datasets/flower_photos/roses/10090824183_d02c613f10_m.jpg'),
WindowsPath('datasets/flower_photos/roses/102501987_3cdb8e5394_n.jpg'),
WindowsPath('datasets/flower_photos/roses/10503217854_e66a804309.jpg'),
WindowsPath('datasets/flower_photos/roses/10894627425_ec76bbc757_n.jpg'),
WindowsPath('datasets/flower_photos/roses/110472418_87b6a3aa98_m.jpg')]
```

```
In [7]: daisy = list(data_dir.glob('daisy/*'))
daisy[:5]
```

```
Out[7]: [WindowsPath('datasets/flower_photos/daisy/100080576_f52e8ee070_n.jpg'),
WindowsPath('datasets/flower_photos/daisy/10140303196_b88d3d6cec.jpg'),
WindowsPath('datasets/flower_photos/daisy/10172379554_b296050f82_n.jpg'),
WindowsPath('datasets/flower_photos/daisy/10172567486_2748826a8b.jpg'),
WindowsPath('datasets/flower_photos/daisy/10172636503_21bededa75_n.jpg')]
```

```
In [8]: dandelion = list(data_dir.glob('dandelion/*'))
dandelion[:5]
```

```
Out[8]: [WindowsPath('datasets/flower_photos/dandelion/10043234166_e6dd915111_n.jpg'),
WindowsPath('datasets/flower_photos/dandelion/10200780773_c6051a7d71_n.jpg'),
WindowsPath('datasets/flower_photos/dandelion/10294487385_92a0676c7d_m.jpg'),
WindowsPath('datasets/flower_photos/dandelion/10437652486_aa86c14985.jpg'),
WindowsPath('datasets/flower_photos/dandelion/10443973_aeb97513fc_m.jpg')]
```

```
In [9]: tulips = list(data_dir.glob('tulips/*'))
tulips[:5]
```

```
Out[9]: [WindowsPath('datasets/flower_photos/tulips/100930342_92e8746431_n.jpg'),
WindowsPath('datasets/flower_photos/tulips/10094729603_eeca3f2cb6.jpg'),
WindowsPath('datasets/flower_photos/tulips/10094731133_94a942463c.jpg'),
WindowsPath('datasets/flower_photos/tulips/10128546863_8de70c610d.jpg'),
WindowsPath('datasets/flower_photos/tulips/10163955604_ae0b830975_n.jpg')]
```

```
In [10]: sunflowers = list(data_dir.glob('sunflowers/*'))
sunflowers[:5]
```

```
Out[10]: [WindowsPath('datasets/flower_photos/sunflowers/1008566138_6927679c8a.jpg'),
WindowsPath('datasets/flower_photos/sunflowers/1022552002_2b93faf9e7_n.jpg'),
WindowsPath('datasets/flower_photos/sunflowers/1022552036_67d33d5bd8_n.jpg'),
WindowsPath('datasets/flower_photos/sunflowers/10386503264_e05387e1f7_m.jpg'),
WindowsPath('datasets/flower_photos/sunflowers/10386522775_4f8c616999_m.jpg')]
```

## Displaying Image

```
In [11]: PIL.Image.open(str(roses[1])) # Roses
```

```
Out[11]:
```



```
In [12]: PIL.Image.open(str(daisy[3])) # daisy
```

```
Out[12]:
```



```
In [13]: PIL.Image.open(str(dandelion[3])) # dandelion
```

Out[13]:



```
In [14]: PIL.Image.open(str(tulips[3])) # tulips
```

Out[14]:



```
In [15]: PIL.Image.open(str(sunflowers[6])) # Sunflowers
```

Out[15]:



Making a dictionary of flower Image and their corresponding paths

```
In [16]: flowers_images_dict = {  
    'roses': list(data_dir.glob('roses/*')),  
    'daisy': list(data_dir.glob('daisy/*')),  
    'dandelion': list(data_dir.glob('dandelion/*')),  
    'sunflowers': list(data_dir.glob('sunflowers/*')),  
    'tulips': list(data_dir.glob('tulips/*'))  
}
```

```
In [17]: flower_labels_dict = {  
    'roses': 0,  
    'daisy': 1,  
    'dandelion': 2,  
    'sunflowers': 3,  
    'tulips': 4  
}
```

Reading image form cv2 (OpenCv) library into 3D-array fromate



```
In [18]: img = cv2.imread(str(flowers_images_dict['roses'][0]))
img
```

```
Out[18]: array([[ 0, 15,  6],
 [ 0, 15,  6],
 [ 0, 17,  8],
 ...,
 [24, 51, 31],
 [25, 52, 32],
 [26, 53, 33]],

 [[ 7, 22, 14],
 [ 7, 22, 14],
 [ 6, 21, 13],
 ...,
 [20, 46, 30],
 [23, 49, 33],
 [25, 51, 35]],

 [[12, 23, 15],
 [12, 23, 15],
 [11, 22, 14],
 ...,
 [20, 42, 30],
 [23, 45, 33],
 [26, 48, 36]],

 ...,

 [[19, 30, 27],
 [14, 24, 18],
 [12, 20, 13],
 ...,
 [ 4, 13,  3],
 [ 0,  8,  1],
 [ 0,  5,  0]],

 [[19, 30, 28],
 [18, 27, 24],
 [15, 23, 16],
 ...,
 [ 3, 12,  2],
 [ 1,  9,  2],
 [ 0,  7,  2]],

 [[ 9, 19, 19],
 [17, 25, 24],
 [22, 29, 24],
 ...,
 [ 1, 12,  2],
 [ 2, 10,  3],
 [ 3, 11,  4]]], dtype=uint8)
```

```
In [19]: img.shape # shape of image in roses at 0th position
```

```
Out[19]: (240, 179, 3)
```

img array manipulation

```
In [20]: cv2.resize(img,(180,180)).shape
```

```
Out[20]: (180, 180, 3)
```

```
In [21]: cv2.resize(img,(180,180))
```

```
Out[21]: array([[ 1, 16,  7],
               [ 1, 16,  7],
               [ 1, 17,  9],
               ...,
               [23, 50, 31],
               [25, 51, 32],
               [26, 52, 33]],

              [[10, 23, 15],
               [10, 23, 15],
               [ 9, 22, 14],
               ...,
               [20, 44, 30],
               [23, 47, 33],
               [26, 50, 36]],

              [[13, 20, 13],
               [12, 20, 13],
               [11, 19, 12],
               ...,
               [21, 43, 30],
               [22, 45, 31],
               [25, 48, 34]],

              ...,

              [[12, 24, 18],
               [11, 22, 15],
               [12, 21, 11],
               ...,
               [ 7, 14,  7],
               [ 2,  8,  2],
               [ 0,  2,  0]],

              [[19, 30, 28],
               [16, 26, 21],
               [14, 22, 15],
               ...,
               [ 3, 12,  2],
               [ 0,  8,  1],
               [ 0,  6,  1]],

              [[11, 21, 20],
               [17, 25, 24],
               [21, 28, 23],
               ...,
               [ 1, 12,  2],
               [ 2, 10,  3],
               [ 3, 10,  4]]], dtype=uint8)
```

### Checking total number of Images in Each Class

```
In [22]: x,y = [], []
         for flowers, img in flowers_images_dict.items():
             print('-',flowers, "has", len(img), "number of images")
```

- roses has 641 number of images
- daisy has 633 number of images
- dandelion has 898 number of images
- sunflowers has 699 number of images
- tulips has 799 number of images

### To store images in resized manner

```
In [24]: x, y= [], []

         for flw_name, images in flowers_images_dict.items():
             for image in images:
                 img = cv2.imread(str(image))
                 resized_img = cv2.resize(img,(180,180))
                 x.append(resized_img)
                 y.append(flower_labels_dict[flw_name])
```

```
In [25]: x = np.array(x)
         y = np.array(y)
```

### Ensuring Data splitting Safely

```
In [27]: from sklearn.model_selection import train_test_split
         x_train, x_test, y_train, y_test = train_test_split(x, y, random_state = 0)
```

```
In [33]: print('Independent variable')
print('Length of training set ',len(x_train), 'and testing set', len(x_test))
```

Independent variable  
Length of training set 2752 and testing set 918

```
In [34]: print('Dependant variable')
print('Length of training set ',len(x_train), 'and testing set', len(x_test))
```

Dependant variable  
Length of training set 2752 and testing set 918

Scaling the values to a specific range

```
In [35]: x_train_scaled = x_train / 255
x_test_scaled = x_test / 255
```

```
In [36]: x_train_scaled[2]
```

```
Out[36]: array([[0.03921569, 0.08627451, 0.10588235],
 [0.14901961, 0.2, 0.21176471],
 [0.10196078, 0.15294118, 0.16470588],
 ...,
 [0.03921569, 0.1372549, 0.12941176],
 [0.05098039, 0.14509804, 0.13333333],
 [0.07058824, 0.15686275, 0.1372549 ]],

 [[0.0627451, 0.1254902, 0.12156863],
 [0.08627451, 0.15294118, 0.14901961],
 [0.10588235, 0.17647059, 0.16862745],
 ...,
 [0.04313725, 0.14117647, 0.1254902 ],
 [0.03921569, 0.1372549, 0.11764706],
 [0.00392157, 0.07058824, 0.03921569]],

 [[0.04313725, 0.12941176, 0.10196078],
 [0.00784314, 0.09411765, 0.06666667],
 [0.02745098, 0.11372549, 0.08627451],
 ...,
 [0.03921569, 0.12941176, 0.11372549],
 [0.00784314, 0.09803922, 0.07843137],
 [0.04313725, 0.12941176, 0.10196078]],

 ...,

 [[0.03137255, 0.10588235, 0.08235294],
 [0.11372549, 0.14117647, 0.14509804],
 [0.18431373, 0.22745098, 0.24705882],
 ...,
 [0.11372549, 0.17647059, 0.29803922],
 [0.02352941, 0.0627451, 0.13333333],
 [0.00392157, 0.03921569, 0.0627451 ]],

 [[0.03529412, 0.08627451, 0.07843137],
 [0.21960784, 0.2745098, 0.29411765],
 [0.23529412, 0.2745098, 0.30196078],
 ...,
 [0.17647059, 0.24313725, 0.37647059],
 [0.0745098, 0.11764706, 0.20784314],
 [0.03921569, 0.09019608, 0.1372549 ]],

 [[0.03529412, 0.09411765, 0.09411765],
 [0.08235294, 0.12941176, 0.16470588],
 [0.13333333, 0.17254902, 0.21176471],
 ...,
 [0.10588235, 0.1372549, 0.24705882],
 [0.19215686, 0.23921569, 0.34901961],
 [0.10588235, 0.15294118, 0.25490196]]])
```

Sample ANN model

```
In [54]: num_classes = 5

model = Sequential([
    layers.Conv2D(16, 3, padding = 'same', activation= 'relu'),
    layers.MaxPooling2D(),
    layers.Conv2D(32, 3, padding = 'same', activation = 'relu'),
    layers.MaxPooling2D(),
    layers.Conv2D(64, 3, padding = 'same', activation = 'relu'),
    layers.MaxPooling2D(),
    layers.Flatten(),
    layers.Dense(128, activation = 'relu'),
    layers.Dense(num_classes, activation = 'softmax')
```

```
])  
model.build()
```

```
In [55]: model.compile(  
        optimizer = 'adam',  
        loss = 'sparse_categorical_crossentropy',  
        metrics = ['accuracy']  
    )
```

```
In [56]: model.fit(x_train_scaled, y_train, epochs = 30)
```

```
Epoch 1/30  
86/86 ————— 32s 237ms/step - accuracy: 0.3630 - loss: 1.4561  
Epoch 2/30  
86/86 ————— 19s 215ms/step - accuracy: 0.6217 - loss: 0.9755  
Epoch 3/30  
86/86 ————— 18s 209ms/step - accuracy: 0.7201 - loss: 0.7451  
Epoch 4/30  
86/86 ————— 17s 198ms/step - accuracy: 0.8018 - loss: 0.5430  
Epoch 5/30  
86/86 ————— 15s 176ms/step - accuracy: 0.8754 - loss: 0.3771  
Epoch 6/30  
86/86 ————— 15s 177ms/step - accuracy: 0.9295 - loss: 0.2142  
Epoch 7/30  
86/86 ————— 15s 175ms/step - accuracy: 0.9771 - loss: 0.0865  
Epoch 8/30  
86/86 ————— 15s 174ms/step - accuracy: 0.9831 - loss: 0.0549  
Epoch 9/30  
86/86 ————— 15s 176ms/step - accuracy: 0.9857 - loss: 0.0580  
Epoch 10/30  
86/86 ————— 15s 174ms/step - accuracy: 0.9860 - loss: 0.0592  
Epoch 11/30  
86/86 ————— 15s 175ms/step - accuracy: 0.9984 - loss: 0.0158  
Epoch 12/30  
86/86 ————— 15s 175ms/step - accuracy: 0.9998 - loss: 0.0050  
Epoch 13/30  
86/86 ————— 15s 176ms/step - accuracy: 0.9998 - loss: 0.0030  
Epoch 14/30  
86/86 ————— 15s 175ms/step - accuracy: 0.9974 - loss: 0.0119  
Epoch 15/30  
86/86 ————— 15s 175ms/step - accuracy: 0.9999 - loss: 0.0029  
Epoch 16/30  
86/86 ————— 15s 176ms/step - accuracy: 0.9995 - loss: 0.0046  
Epoch 17/30  
86/86 ————— 15s 175ms/step - accuracy: 0.9997 - loss: 0.0017  
Epoch 18/30  
86/86 ————— 15s 176ms/step - accuracy: 0.9993 - loss: 0.0031  
Epoch 19/30  
86/86 ————— 15s 175ms/step - accuracy: 1.0000 - loss: 4.8150e-04  
Epoch 20/30  
86/86 ————— 16s 178ms/step - accuracy: 0.9999 - loss: 0.0019  
Epoch 21/30  
86/86 ————— 15s 176ms/step - accuracy: 1.0000 - loss: 0.0010  
Epoch 22/30  
86/86 ————— 15s 176ms/step - accuracy: 0.9996 - loss: 0.0035  
Epoch 23/30  
86/86 ————— 16s 178ms/step - accuracy: 0.9998 - loss: 0.0016  
Epoch 24/30  
86/86 ————— 15s 177ms/step - accuracy: 0.9998 - loss: 0.0016  
Epoch 25/30  
86/86 ————— 15s 176ms/step - accuracy: 0.9999 - loss: 0.0014  
Epoch 26/30  
86/86 ————— 15s 176ms/step - accuracy: 0.9995 - loss: 0.0036  
Epoch 27/30  
86/86 ————— 15s 175ms/step - accuracy: 0.9995 - loss: 0.0036  
Epoch 28/30  
86/86 ————— 15s 176ms/step - accuracy: 0.9994 - loss: 0.0031  
Epoch 29/30  
86/86 ————— 15s 175ms/step - accuracy: 0.9996 - loss: 0.0015  
Epoch 30/30  
86/86 ————— 15s 177ms/step - accuracy: 0.9996 - loss: 0.0012
```

```
Out[56]: <keras.src.callbacks.history.History at 0x1adffe8a5f0>
```

#### case of Overfitting

```
In [57]: model.evaluate(x_test_scaled, y_test)
```

```
29/29 ————— 3s 54ms/step - accuracy: 0.6727 - loss: 2.0404
```

```
Out[57]: [2.0933127403259277, 0.6786492466926575]
```

```
In [58]: predictions = model.predict(x_test_scaled)
```

```
In [59]: predictions
```

```
Out[59]: array([[6.2679799e-09, 1.0000000e+00, 8.4595135e-12, 7.7876697e-19,
 1.6252314e-09],
 [9.9883670e-01, 6.0127268e-04, 5.1136492e-08, 1.7579733e-06,
 5.6040555e-04],
 [8.4943288e-09, 1.4560351e-04, 9.9985421e-01, 2.0568297e-11,
 7.1137620e-08],
 ...,
 [2.6731379e-02, 9.6613689e-08, 3.4778576e-08, 9.5257610e-01,
 2.0692384e-02],
 [5.0557271e-04, 9.9943298e-01, 4.2312597e-05, 1.4935048e-05,
 4.2120209e-06],
 [1.9477045e-05, 7.9999611e-11, 8.3758577e-04, 9.7028506e-01,
 2.8857935e-02]], dtype=float32)
```

## Data Augmentation

```
In [64]: img_height, img_width = 180,180
augmentation = keras.Sequential([
    layers.RandomZoom(0.3),
    layers.RandomContrast(0.9),
    layers.RandomFlip('horizontal',
                      input_shape = (img_height,
                                     img_width,
                                     3)),
    layers.RandomRotation(0.1)
])
```

C:\Users\Satoshi\AppData\Local\Programs\Python\Python310\lib\site-packages\keras\src\layers\preprocessing\tf\_data\_layer.py:18: UserWarning: Do not pass an `input\_shape`/`input\_dim` argument to a layer. When using Sequential models, prefer using an `Input(shape)` object as the first layer in the model instead.  
 super().\_\_init\_\_(\*\*kwargs)

## ANN Model after Augmentation

```
In [66]: num_classes = 5

model_2 = Sequential([
    augmentation,
    layers.Conv2D(16, 3, padding = 'same', activation = 'relu'),
    layers.MaxPooling2D(),
    layers.Conv2D(32, 3, padding = 'same', activation = 'relu'),
    layers.MaxPooling2D(),
    layers.Conv2D(64, 3, padding = 'same', activation = 'relu'),
    layers.MaxPooling2D(),
    layers.Dropout(0.2),
    layers.Flatten(),
    layers.Dense(128, activation = 'relu'),
    layers.Dense(num_classes, activation = 'softmax')
])
model_2.build()
```

```
In [68]: model_2.compile(
    optimizer = 'adam',
    loss = 'sparse_categorical_crossentropy',
    metrics = ['accuracy']
)
```

```
In [72]: model_2.fit(x_train_scaled, y_train, epochs = 30)
```

```

Epoch 1/30
86/86 ————— 19s 221ms/step - accuracy: 0.5237 - loss: 1.1423
Epoch 2/30
86/86 ————— 19s 217ms/step - accuracy: 0.5571 - loss: 1.1186
Epoch 3/30
86/86 ————— 19s 214ms/step - accuracy: 0.5566 - loss: 1.0976
Epoch 4/30
86/86 ————— 18s 211ms/step - accuracy: 0.5965 - loss: 1.0353
Epoch 5/30
86/86 ————— 18s 210ms/step - accuracy: 0.5965 - loss: 1.0076
Epoch 6/30
86/86 ————— 19s 222ms/step - accuracy: 0.6207 - loss: 0.9818
Epoch 7/30
86/86 ————— 19s 218ms/step - accuracy: 0.6112 - loss: 0.9768
Epoch 8/30
86/86 ————— 20s 226ms/step - accuracy: 0.6637 - loss: 0.8841
Epoch 9/30
86/86 ————— 18s 212ms/step - accuracy: 0.6510 - loss: 0.9367
Epoch 10/30
86/86 ————— 18s 211ms/step - accuracy: 0.6440 - loss: 0.8876
Epoch 11/30
86/86 ————— 18s 212ms/step - accuracy: 0.6420 - loss: 0.8740
Epoch 12/30
86/86 ————— 18s 211ms/step - accuracy: 0.6664 - loss: 0.8737
Epoch 13/30
86/86 ————— 18s 212ms/step - accuracy: 0.6878 - loss: 0.8134
Epoch 14/30
86/86 ————— 19s 214ms/step - accuracy: 0.6649 - loss: 0.8354
Epoch 15/30
86/86 ————— 22s 246ms/step - accuracy: 0.7059 - loss: 0.7844
Epoch 16/30
86/86 ————— 20s 228ms/step - accuracy: 0.6847 - loss: 0.8000
Epoch 17/30
86/86 ————— 19s 219ms/step - accuracy: 0.7245 - loss: 0.7348
Epoch 18/30
86/86 ————— 21s 238ms/step - accuracy: 0.6726 - loss: 0.8390
Epoch 19/30
86/86 ————— 20s 225ms/step - accuracy: 0.7238 - loss: 0.7308
Epoch 20/30
86/86 ————— 19s 214ms/step - accuracy: 0.7062 - loss: 0.7495
Epoch 21/30
86/86 ————— 19s 215ms/step - accuracy: 0.7379 - loss: 0.6791
Epoch 22/30
86/86 ————— 19s 214ms/step - accuracy: 0.7330 - loss: 0.6838
Epoch 23/30
86/86 ————— 19s 213ms/step - accuracy: 0.7366 - loss: 0.6915
Epoch 24/30
86/86 ————— 19s 215ms/step - accuracy: 0.7441 - loss: 0.6811
Epoch 25/30
86/86 ————— 19s 214ms/step - accuracy: 0.7643 - loss: 0.6412
Epoch 26/30
86/86 ————— 21s 242ms/step - accuracy: 0.7403 - loss: 0.6868
Epoch 27/30
86/86 ————— 20s 232ms/step - accuracy: 0.7350 - loss: 0.6874
Epoch 28/30
86/86 ————— 19s 223ms/step - accuracy: 0.7651 - loss: 0.6178
Epoch 29/30
86/86 ————— 19s 222ms/step - accuracy: 0.7560 - loss: 0.6400
Epoch 30/30
86/86 ————— 19s 221ms/step - accuracy: 0.7429 - loss: 0.6490

```

```
Out[72]: <keras.src.callbacks.history.History at 0x1aee65b63e0>
```

```
In [74]: model_2.evaluate(x_test_scaled, y_test)
```

```
29/29 ————— 3s 56ms/step - accuracy: 0.7386 - loss: 0.6836
```

```
Out[74]: [0.7021130919456482, 0.7352941036224365]
```

## Conclusion

Data augmentation is a powerful technique to enhance the performance and robustness of machine learning models. By applying various transformations to the training data, models can generalize better and perform well on unseen data. This is crucial in developing robust and reliable AI systems.