In [16]:
```
!pip3 install tensorflow
```

```
Requirement already satisfied: tensorflow in c:\users\dell\anaconda3\lib\site-package
s (2.12.0)
Requirement already satisfied: tensorflow-intel==2.12.0 in c:\users\dell\anaconda3\li
b\site-packages (from tensorflow) (2.12.0)
Requirement already satisfied: termcolor>=1.1.0 in c:\users\dell\anaconda3\lib\site-p
ackages (from tensorflow-intel==2.12.0->tensorflow) (2.3.0)
Requirement already satisfied: h5py>=2.9.0 in c:\users\dell\anaconda3\lib\site-packag
es (from tensorflow-intel==2.12.0->tensorflow) (3.7.0)
Requirement already satisfied: gast<=0.4.0,>=0.2.1 in c:\users\dell\anaconda3\lib\sit
e-packages (from tensorflow-intel==2.12.0->tensorflow) (0.4.0)
Requirement already satisfied: protobuf!=4.21.0,!=4.21.1,!=4.21.2,!=4.21.3,!=4.21.4,!
=4.21.5,<5.0.0dev,>=3.20.3 in c:\users\dell\anaconda3\lib\site-packages (from tensorf
low-intel==2.12.0->tensorflow) (4.23.3)
Requirement already satisfied: keras<2.13,>=2.12.0 in c:\users\dell\anaconda3\lib\sit
e-packages (from tensorflow-intel==2.12.0->tensorflow) (2.12.0)
Requirement already satisfied: typing-extensions>=3.6.6 in c:\users\dell\anaconda3\li
b\site-packages (from tensorflow-intel==2.12.0->tensorflow) (4.3.0)
Requirement already satisfied: astunparse>=1.6.0 in c:\users\dell\anaconda3\lib\site-
packages (from tensorflow-intel==2.12.0->tensorflow) (1.6.3)
Requirement already satisfied: setuptools in c:\users\dell\anaconda3\lib\site-package
s (from tensorflow-intel==2.12.0->tensorflow) (63.4.1)
Requirement already satisfied: tensorflow-estimator<2.13,>=2.12.0 in c:\users\dell\an
aconda3\lib\site-packages (from tensorflow-intel==2.12.0->tensorflow) (2.12.0)
Requirement already satisfied: jax>=0.3.15 in c:\users\dell\anaconda3\lib\site-packag
es (from tensorflow-intel==2.12.0->tensorflow) (0.4.13)
Requirement already satisfied: packaging in c:\users\dell\anaconda3\lib\site-packages
(from tensorflow-intel==2.12.0->tensorflow) (21.3)
Requirement already satisfied: six>=1.12.0 in c:\users\dell\anaconda3\lib\site-packag
es (from tensorflow-intel==2.12.0->tensorflow) (1.16.0)
Requirement already satisfied: wrapt<1.15,>=1.11.0 in c:\users\dell\anaconda3\lib\sit
e-packages (from tensorflow-intel==2.12.0->tensorflow) (1.14.1)
Requirement already satisfied: numpy<1.24,>=1.22 in c:\users\dell\anaconda3\lib\site-
packages (from tensorflow-intel==2.12.0->tensorflow) (1.23.5)
Requirement already satisfied: google-pasta>=0.1.1 in c:\users\dell\anaconda3\lib\sit
e-packages (from tensorflow-intel==2.12.0->tensorflow) (0.2.0)
Requirement already satisfied: tensorflow-io-gcs-filesystem>=0.23.1 in c:\users\dell
\anaconda3\lib\site-packages (from tensorflow-intel==2.12.0->tensorflow) (0.31.0)
Requirement already satisfied: opt-einsum>=2.3.2 in c:\users\dell\anaconda3\lib\site-
packages (from tensorflow-intel==2.12.0->tensorflow) (3.3.0)
Requirement already satisfied: flatbuffers>=2.0 in c:\users\dell\anaconda3\lib\site-p
ackages (from tensorflow-intel==2.12.0->tensorflow) (23.5.26)
Requirement already satisfied: libclang>=13.0.0 in c:\users\dell\anaconda3\lib\site-p
ackages (from tensorflow-intel==2.12.0->tensorflow) (16.0.0)
Requirement already satisfied: tensorboard<2.13,>=2.12 in c:\users\dell\anaconda3\lib
\site-packages (from tensorflow-intel==2.12.0->tensorflow) (2.12.3)
Requirement already satisfied: absl-py>=1.0.0 in c:\users\dell\anaconda3\lib\site-pac
kages (from tensorflow-intel==2.12.0->tensorflow) (1.4.0)
Requirement already satisfied: grpcio<2.0,>=1.24.3 in c:\users\dell\anaconda3\lib\sit
e-packages (from tensorflow-intel==2.12.0->tensorflow) (1.56.0)
Requirement already satisfied: wheel<1.0,>=0.23.0 in c:\users\dell\anaconda3\lib\site
-packages (from astunparse>=1.6.0->tensorflow-intel==2.12.0->tensorflow) (0.37.1)
Requirement already satisfied: ml-dtypes>=0.1.0 in c:\users\dell\anaconda3\lib\site-p
ackages (from jax>=0.3.15->tensorflow-intel==2.12.0->tensorflow) (0.2.0)
Requirement already satisfied: scipy>=1.7 in c:\users\dell\anaconda3\lib\site-package
s (from jax>=0.3.15->tensorflow-intel==2.12.0->tensorflow) (1.9.1)
Requirement already satisfied: importlib-metadata>=4.6 in c:\users\dell\anaconda3\lib
\site-packages (from jax>=0.3.15->tensorflow-intel==2.12.0->tensorflow) (4.11.3)
Requirement already satisfied: google-auth-oauthlib<1.1,>=0.5 in c:\users\dell\anacon
da3\lib\site-packages (from tensorboard<2.13,>=2.12->tensorflow-intel==2.12.0->tensor
flow) (1.0.0)
```

```
Requirement already satisfied: markdown>=2.6.8 in c:\users\dell\anaconda3\lib\site-pa
ckages (from tensorboard<2.13,>=2.12->tensorflow-intel==2.12.0->tensorflow) (3.3.4)
Requirement already satisfied: google-auth<3,>=1.6.3 in c:\users\dell\anaconda3\lib\s
ite-packages (from tensorboard<2.13,>=2.12->tensorflow-intel==2.12.0->tensorflow) (2.
20.0)
Requirement already satisfied: tensorboard-data-server<0.8.0,>=0.7.0 in c:\users\dell
\anaconda3\lib\site-packages (from tensorboard<2.13,>=2.12->tensorflow-intel==2.12.0-
>tensorflow) (0.7.1)
Requirement already satisfied: werkzeug>=1.0.1 in c:\users\dell\anaconda3\lib\site-pa
ckages (from tensorboard<2.13,>=2.12->tensorflow-intel==2.12.0->tensorflow) (2.0.3)
Requirement already satisfied: requests<3,>=2.21.0 in c:\users\dell\anaconda3\lib\sit
e-packages (from tensorboard<2.13,>=2.12->tensorflow-intel==2.12.0->tensorflow) (2.2
8.1)
Requirement already satisfied: pyparsing!=3.0.5,>=2.0.2 in c:\users\dell\anaconda3\li
b\site-packages (from packaging->tensorflow-intel==2.12.0->tensorflow) (3.0.9)
Requirement already satisfied: pyasn1-modules>=0.2.1 in c:\users\dell\anaconda3\lib\s
ite-packages (from google-auth<3,>=1.6.3->tensorboard<2.13,>=2.12->tensorflow-intel==
2.12.0->tensorflow) (0.2.8)
Requirement already satisfied: rsa<5,>=3.1.4 in c:\users\dell\anaconda3\lib\site-pack
ages (from google-auth<3,>=1.6.3->tensorboard<2.13,>=2.12->tensorflow-intel==2.12.0->
tensorflow) (4.9)
Requirement already satisfied: cachetools<6.0,>=2.0.0 in c:\users\dell\anaconda3\lib
\site-packages (from google-auth<3,>=1.6.3->tensorboard<2.13,>=2.12->tensorflow-intel
==2.12.0->tensorflow) (5.3.1)
Requirement already satisfied: urllib3<2.0 in c:\users\dell\anaconda3\lib\site-packag
es (from google-auth<3,>=1.6.3->tensorboard<2.13,>=2.12->tensorflow-intel==2.12.0->te
nsorflow) (1.26.11)
Requirement already satisfied: requests-oauthlib>=0.7.0 in c:\users\dell\anaconda3\li
b\site-packages (from google-auth-oauthlib<1.1,>=0.5->tensorboard<2.13,>=2.12->tensor
flow-intel==2.12.0->tensorflow) (1.3.1)
Requirement already satisfied: zipp>=0.5 in c:\users\dell\anaconda3\lib\site-packages
(from importlib-metadata>=4.6->jax>=0.3.15->tensorflow-intel==2.12.0->tensorflow) (3.
8.0)
Requirement already satisfied: charset-normalizer<3,>=2 in c:\users\dell\anaconda3\li
b\site-packages (from requests<3,>=2.21.0->tensorboard<2.13,>=2.12->tensorflow-intel=
=2.12.0->tensorflow) (2.0.4)
Requirement already satisfied: idna<4,>=2.5 in c:\users\dell\anaconda3\lib\site-packa
ges (from requests<3,>=2.21.0->tensorboard<2.13,>=2.12->tensorflow-intel==2.12.0->ten
sorflow) (3.3)
Requirement already satisfied: certifi>=2017.4.17 in c:\users\dell\anaconda3\lib\site
-packages (from requests<3,>=2.21.0->tensorboard<2.13,>=2.12->tensorflow-intel==2.12.
0->tensorflow) (2022.9.14)
Requirement already satisfied: pyasn1<0.5.0,>=0.4.6 in c:\users\dell\anaconda3\lib\si
te-packages (from pyasn1-modules>=0.2.1->google-auth<3,>=1.6.3->tensorboard<2.13,>=2.
12->tensorflow-intel==2.12.0->tensorflow) (0.4.8)
Requirement already satisfied: oauthlib>=3.0.0 in c:\users\dell\anaconda3\lib\site-pa
ckages (from requests-oauthlib>=0.7.0->google-auth-oauthlib<1.1,>=0.5->tensorboard<2.
13,>=2.12->tensorflow-intel==2.12.0->tensorflow) (3.2.2)
WARNING: Ignoring invalid distribution -atplotlib (c:\users\dell\anaconda3\lib\site-p
ackages)
WARNING: Ignoring invalid distribution -atplotlib (c:\users\dell\anaconda3\lib\site-p
ackages)
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ackages)
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ackages)
WARNING: Ignoring invalid distribution -atplotlib (c:\users\dell\anaconda3\lib\site-p
ackages)
```

In [17]:
```
import tensorflow as tf

print(tf.__version__)
```

```
2.12.0
```

In [18]:
```
    Directory_Training_ = 'C:/Users/Dell/Desktop/asl_alphabet_train/asl_alphabet_trair
    Directory_Testing = 'C:/Users/Dell/Desktop/asl_alphabet_test/asl_alphabet_test/'
```

In [19]:
```
!pip install opencv-python
```

```
Requirement already satisfied: opencv-python in c:\users\dell\anaconda3\lib\site-pack
ages (4.7.0.72)
Requirement already satisfied: numpy>=1.17.3 in c:\users\dell\anaconda3\lib\site-pack
ages (from opencv-python) (1.23.5)
WARNING: Ignoring invalid distribution -atplotlib (c:\users\dell\anaconda3\lib\site-p
ackages)
WARNING: Ignoring invalid distribution -atplotlib (c:\users\dell\anaconda3\lib\site-p
ackages)
WARNING: Ignoring invalid distribution -atplotlib (c:\users\dell\anaconda3\lib\site-p
ackages)
WARNING: Ignoring invalid distribution -atplotlib (c:\users\dell\anaconda3\lib\site-p
ackages)
WARNING: Ignoring invalid distribution -atplotlib (c:\users\dell\anaconda3\lib\site-p
ackages)
WARNING: Ignoring invalid distribution -atplotlib (c:\users\dell\anaconda3\lib\site-p
ackages)
```

In [20]:
```
#%matplotlib inline  # Enables displaying plots directly in the Jupyter Notebook or IP
```

In [21]:
```
import numpy as nps_  # Library for numerical operations
import matplotlib.image as mpimgs_  # Library for reading and displaying images
import matplotlib.pyplot as plts_  # Library for plotting and visualization

import cv2  # Library for image processing
import os  # Library for file and directory operations
import random  # Library for generating random numbers

row_number = 1  # Number of rows for subplots
column_number = 5  # Number of columns for subplots

CATS = os.listdir(Directory_Training_)  # Get the list of categories (folders) in the

random.seed(13)  # Set a random seed for reproducibility

CAT = CATS[random.randint(1, 30)]  # Select a random category from the list

for j in range(column_number):
    subplot = plts_.subplot(row_number, column_number, j + 1)  # Create a subplot for
    subplot.axis('Off')  # Turn off the subplot's axis
    subplot.set_title(CAT)  # Set the title of the subplot

    image_path = os.path.join(
        Directory_Training_,
        str(CAT),
        str(CAT) + str(random.randint(1, 1000)) + '.jpg'
    )  # Generate a random image path for the selected category
```

```
    img_ = mpimgs_.imread(image_path)  # Read the image from the generated path
    plts_.imshow(img_)  # Display the image on the subplot

plts_.show()  # Show the subplots
```

In [22]:
```
!pip install --upgrade tensorflow
```

```
Requirement already satisfied: tensorflow in c:\users\dell\anaconda3\lib\site-package
s (2.12.0)
Requirement already satisfied: tensorflow-intel==2.12.0 in c:\users\dell\anaconda3\li
b\site-packages (from tensorflow) (2.12.0)
Requirement already satisfied: jax>=0.3.15 in c:\users\dell\anaconda3\lib\site-packag
es (from tensorflow-intel==2.12.0->tensorflow) (0.4.13)
Requirement already satisfied: six>=1.12.0 in c:\users\dell\anaconda3\lib\site-packag
es (from tensorflow-intel==2.12.0->tensorflow) (1.16.0)
Requirement already satisfied: grpcio<2.0,>=1.24.3 in c:\users\dell\anaconda3\lib\sit
e-packages (from tensorflow-intel==2.12.0->tensorflow) (1.56.0)
Requirement already satisfied: absl-py>=1.0.0 in c:\users\dell\anaconda3\lib\site-pac
kages (from tensorflow-intel==2.12.0->tensorflow) (1.4.0)
Requirement already satisfied: tensorflow-io-gcs-filesystem>=0.23.1 in c:\users\dell
\anaconda3\lib\site-packages (from tensorflow-intel==2.12.0->tensorflow) (0.31.0)
Requirement already satisfied: wrapt<1.15,>=1.11.0 in c:\users\dell\anaconda3\lib\sit
e-packages (from tensorflow-intel==2.12.0->tensorflow) (1.14.1)
Requirement already satisfied: astunparse>=1.6.0 in c:\users\dell\anaconda3\lib\site-
packages (from tensorflow-intel==2.12.0->tensorflow) (1.6.3)
Requirement already satisfied: tensorflow-estimator<2.13,>=2.12.0 in c:\users\dell\an
aconda3\lib\site-packages (from tensorflow-intel==2.12.0->tensorflow) (2.12.0)
Requirement already satisfied: numpy<1.24,>=1.22 in c:\users\dell\anaconda3\lib\site-
packages (from tensorflow-intel==2.12.0->tensorflow) (1.23.5)
Requirement already satisfied: tensorboard<2.13,>=2.12 in c:\users\dell\anaconda3\lib
\site-packages (from tensorflow-intel==2.12.0->tensorflow) (2.12.3)
Requirement already satisfied: flatbuffers>=2.0 in c:\users\dell\anaconda3\lib\site-p
ackages (from tensorflow-intel==2.12.0->tensorflow) (23.5.26)
Requirement already satisfied: termcolor>=1.1.0 in c:\users\dell\anaconda3\lib\site-p
ackages (from tensorflow-intel==2.12.0->tensorflow) (2.3.0)
Requirement already satisfied: gast<=0.4.0,>=0.2.1 in c:\users\dell\anaconda3\lib\sit
e-packages (from tensorflow-intel==2.12.0->tensorflow) (0.4.0)
Requirement already satisfied: keras<2.13,>=2.12.0 in c:\users\dell\anaconda3\lib\sit
e-packages (from tensorflow-intel==2.12.0->tensorflow) (2.12.0)
Requirement already satisfied: packaging in c:\users\dell\anaconda3\lib\site-packages
(from tensorflow-intel==2.12.0->tensorflow) (21.3)
Requirement already satisfied: google-pasta>=0.1.1 in c:\users\dell\anaconda3\lib\sit
e-packages (from tensorflow-intel==2.12.0->tensorflow) (0.2.0)
Requirement already satisfied: opt-einsum>=2.3.2 in c:\users\dell\anaconda3\lib\site-
packages (from tensorflow-intel==2.12.0->tensorflow) (3.3.0)
Requirement already satisfied: h5py>=2.9.0 in c:\users\dell\anaconda3\lib\site-packag
es (from tensorflow-intel==2.12.0->tensorflow) (3.7.0)
Requirement already satisfied: libclang>=13.0.0 in c:\users\dell\anaconda3\lib\site-p
ackages (from tensorflow-intel==2.12.0->tensorflow) (16.0.0)
Requirement already satisfied: setuptools in c:\users\dell\anaconda3\lib\site-package
s (from tensorflow-intel==2.12.0->tensorflow) (63.4.1)
Requirement already satisfied: typing-extensions>=3.6.6 in c:\users\dell\anaconda3\li
b\site-packages (from tensorflow-intel==2.12.0->tensorflow) (4.3.0)
Requirement already satisfied: protobuf!=4.21.0,!=4.21.1,!=4.21.2,!=4.21.3,!=4.21.4,!
=4.21.5,<5.0.0dev,>=3.20.3 in c:\users\dell\anaconda3\lib\site-packages (from tensorf
low-intel==2.12.0->tensorflow) (4.23.3)
Requirement already satisfied: wheel<1.0,>=0.23.0 in c:\users\dell\anaconda3\lib\site
-packages (from astunparse>=1.6.0->tensorflow-intel==2.12.0->tensorflow) (0.37.1)
Requirement already satisfied: ml-dtypes>=0.1.0 in c:\users\dell\anaconda3\lib\site-p
ackages (from jax>=0.3.15->tensorflow-intel==2.12.0->tensorflow) (0.2.0)
Requirement already satisfied: importlib-metadata>=4.6 in c:\users\dell\anaconda3\lib
\site-packages (from jax>=0.3.15->tensorflow-intel==2.12.0->tensorflow) (4.11.3)
Requirement already satisfied: scipy>=1.7 in c:\users\dell\anaconda3\lib\site-package
s (from jax>=0.3.15->tensorflow-intel==2.12.0->tensorflow) (1.9.1)
Requirement already satisfied: google-auth<3,>=1.6.3 in c:\users\dell\anaconda3\lib\s
ite-packages (from tensorboard<2.13,>=2.12->tensorflow-intel==2.12.0->tensorflow) (2.
20.0)
```

```
Requirement already satisfied: tensorboard-data-server<0.8.0,>=0.7.0 in c:\users\dell
\anaconda3\lib\site-packages (from tensorboard<2.13,>=2.12->tensorflow-intel==2.12.0-
>tensorflow) (0.7.1)
Requirement already satisfied: requests<3,>=2.21.0 in c:\users\dell\anaconda3\lib\sit
e-packages (from tensorboard<2.13,>=2.12->tensorflow-intel==2.12.0->tensorflow) (2.2
8.1)
Requirement already satisfied: markdown>=2.6.8 in c:\users\dell\anaconda3\lib\site-pa
ckages (from tensorboard<2.13,>=2.12->tensorflow-intel==2.12.0->tensorflow) (3.3.4)
Requirement already satisfied: google-auth-oauthlib<1.1,>=0.5 in c:\users\dell\anacon
da3\lib\site-packages (from tensorboard<2.13,>=2.12->tensorflow-intel==2.12.0->tensor
flow) (1.0.0)
Requirement already satisfied: werkzeug>=1.0.1 in c:\users\dell\anaconda3\lib\site-pa
ckages (from tensorboard<2.13,>=2.12->tensorflow-intel==2.12.0->tensorflow) (2.0.3)
Requirement already satisfied: pyparsing!=3.0.5,>=2.0.2 in c:\users\dell\anaconda3\li
b\site-packages (from packaging->tensorflow-intel==2.12.0->tensorflow) (3.0.9)
Requirement already satisfied: urllib3<2.0 in c:\users\dell\anaconda3\lib\site-packag
es (from google-auth<3,>=1.6.3->tensorboard<2.13,>=2.12->tensorflow-intel==2.12.0->te
nsorflow) (1.26.11)
Requirement already satisfied: rsa<5,>=3.1.4 in c:\users\dell\anaconda3\lib\site-pack
ages (from google-auth<3,>=1.6.3->tensorboard<2.13,>=2.12->tensorflow-intel==2.12.0->
tensorflow) (4.9)
Requirement already satisfied: pyasn1-modules>=0.2.1 in c:\users\dell\anaconda3\lib\s
ite-packages (from google-auth<3,>=1.6.3->tensorboard<2.13,>=2.12->tensorflow-intel==
2.12.0->tensorflow) (0.2.8)
Requirement already satisfied: cachetools<6.0,>=2.0.0 in c:\users\dell\anaconda3\lib
\site-packages (from google-auth<3,>=1.6.3->tensorboard<2.13,>=2.12->tensorflow-intel
==2.12.0->tensorflow) (5.3.1)
Requirement already satisfied: requests-oauthlib>=0.7.0 in c:\users\dell\anaconda3\li
b\site-packages (from google-auth-oauthlib<1.1,>=0.5->tensorboard<2.13,>=2.12->tensor
flow-intel==2.12.0->tensorflow) (1.3.1)
Requirement already satisfied: zipp>=0.5 in c:\users\dell\anaconda3\lib\site-packages
(from importlib-metadata>=4.6->jax>=0.3.15->tensorflow-intel==2.12.0->tensorflow) (3.
8.0)
Requirement already satisfied: idna<4,>=2.5 in c:\users\dell\anaconda3\lib\site-packa
ges (from requests<3,>=2.21.0->tensorboard<2.13,>=2.12->tensorflow-intel==2.12.0->ten
sorflow) (3.3)
Requirement already satisfied: charset-normalizer<3,>=2 in c:\users\dell\anaconda3\li
b\site-packages (from requests<3,>=2.21.0->tensorboard<2.13,>=2.12->tensorflow-intel=
=2.12.0->tensorflow) (2.0.4)
Requirement already satisfied: certifi>=2017.4.17 in c:\users\dell\anaconda3\lib\site
-packages (from requests<3,>=2.21.0->tensorboard<2.13,>=2.12->tensorflow-intel==2.12.
0->tensorflow) (2022.9.14)
Requirement already satisfied: pyasn1<0.5.0,>=0.4.6 in c:\users\dell\anaconda3\lib\si
te-packages (from pyasn1-modules>=0.2.1->google-auth<3,>=1.6.3->tensorboard<2.13,>=2.
12->tensorflow-intel==2.12.0->tensorflow) (0.4.8)
Requirement already satisfied: oauthlib>=3.0.0 in c:\users\dell\anaconda3\lib\site-pa
ckages (from requests-oauthlib>=0.7.0->google-auth-oauthlib<1.1,>=0.5->tensorboard<2.
13,>=2.12->tensorflow-intel==2.12.0->tensorflow) (3.2.2)
WARNING: Ignoring invalid distribution -atplotlib (c:\users\dell\anaconda3\lib\site-p
ackages)
WARNING: Ignoring invalid distribution -atplotlib (c:\users\dell\anaconda3\lib\site-p
ackages)
WARNING: Ignoring invalid distribution -atplotlib (c:\users\dell\anaconda3\lib\site-p
ackages)
WARNING: Ignoring invalid distribution -atplotlib (c:\users\dell\anaconda3\lib\site-p
ackages)
WARNING: Ignoring invalid distribution -atplotlib (c:\users\dell\anaconda3\lib\site-p
ackages)
WARNING: Ignoring invalid distribution -atplotlib (c:\users\dell\anaconda3\lib\site-p
ackages)
```

In [23]:
```
from tensorflow.keras.preprocessing.image import ImageDataGenerator as  Image_Data_Ger

Size_of_image = 200  # Size of the images (width and height)
Size_of_batch = 64  # Number of images per batch

# Data augmentation and preprocessing settings
Gen_Data_ = Image_Data_Gen_(
    samplewise_center=True,  # Normalize each image by subtracting the mean
    samplewise_std_normalization=True,  # Normalize each image by dividing by the star
    brightness_range=[0.8, 1.0],  # Randomly adjust brightness of the images
    zoom_range=[1.0, 1.2],  # Randomly zoom into the images
    validation_split=0.1  # Split the data into training and validation sets (90% trai
)

# Generate training data from the training directory
Gen_Train_ = Gen_Data_.flow_from_directory(
    Directory_Training_,
    target_size=(Size_of_image, Size_of_image),  # Resize images to the specified size
    shuffle=True,  # Shuffle the order of the images
    seed=13,  # Set a random seed for reproducibility
    class_mode='categorical',  # Use categorical labels
    batch_size=Size_of_batch,  # Number of images per batch
    subset="training"  # Subset of the data (training set)
)

# Generate validation data from the training directory
Gen_Validation_ = Gen_Data_.flow_from_directory(
    Directory_Training_,
    target_size=(Size_of_image, Size_of_image),  # Resize images to the specified size
    shuffle=True,  # Shuffle the order of the images
    seed=13,  # Set a random seed for reproducibility
    class_mode='categorical',  # Use categorical labels
    batch_size=Size_of_batch,  # Number of images per batch
    subset="validation"  # Subset of the data (validation set)
)
```

```
Found 78300 images belonging to 29 classes.
Found 8700 images belonging to 29 classes.
```

In [24]:
```
!pip install wget
```

```
Requirement already satisfied: wget in c:\users\dell\anaconda3\lib\site-packages (3.
2)
WARNING: Ignoring invalid distribution -atplotlib (c:\users\dell\anaconda3\lib\site-p
ackages)
WARNING: Ignoring invalid distribution -atplotlib (c:\users\dell\anaconda3\lib\site-p
ackages)
WARNING: Ignoring invalid distribution -atplotlib (c:\users\dell\anaconda3\lib\site-p
ackages)
WARNING: Ignoring invalid distribution -atplotlib (c:\users\dell\anaconda3\lib\site-p
ackages)
WARNING: Ignoring invalid distribution -atplotlib (c:\users\dell\anaconda3\lib\site-p
ackages)
WARNING: Ignoring invalid distribution -atplotlib (c:\users\dell\anaconda3\lib\site-p
ackages)
```

In [25]:
```
import wget  # Library for downloading files from the web

URL1_ = "https://storage.googleapis.com/mledu-datasets/inception_v3_weights_tf_dim_ord
```

```
wget.download(URL1_)
```

```
100% [..........................................................................] 87910
968 / 87910968
```

Out[25]:
```
'inception_v3_weights_tf_dim_ordering_tf_kernels_notop (8).h5'
```

In [26]:
```
from tensorflow.keras import layers  # Library for building neural network layers
from tensorflow.keras import Model  # Class for creating custom models

from tensorflow.keras.applications.inception_v3 import InceptionV3  # Pre-trained Ince

WEIGHTS_FILE = 'c:/Users/Chandana/OneDrive/Desktop/inception_v3_weights_tf_dim_orderir

inception_v3_model = InceptionV3(
    input_shape=(Size_of_image, Size_of_image, 3),
    include_top=False,
    weights='imagenet'
)
model = inception_v3_model

# Freeze the layers except for the last 2 blocks
for layer in model.layers[:249]:
    layer.trainable = False

# Unfreeze the layers in the last 2 blocks
for layer in model.layers[249:]:
    layer.trainable = True

inception_v3_model.summary()
```

```
Model: "inception_v3"
__________________________________________________________________________________________________
 Layer (type)                   Output Shape         Param #     Connected to
==================================================================================================
 input_2 (InputLayer)           [(None, 200, 200, 3  0           []
                                )]

 conv2d_94 (Conv2D)             (None, 99, 99, 32)   864         ['input_2[0][0]']

 batch_normalization_94 (BatchN  (None, 99, 99, 32)  96          ['conv2d_94[0][0]']
 ormalization)

 activation_94 (Activation)     (None, 99, 99, 32)   0           ['batch_normalizatio
n_94[0][0]']

 conv2d_95 (Conv2D)             (None, 97, 97, 32)   9216        ['activation_94[0]
[0]']

 batch_normalization_95 (BatchN  (None, 97, 97, 32)  96          ['conv2d_95[0][0]']
 ormalization)

 activation_95 (Activation)     (None, 97, 97, 32)   0           ['batch_normalizatio
n_95[0][0]']

 conv2d_96 (Conv2D)             (None, 97, 97, 64)   18432       ['activation_95[0]
[0]']

 batch_normalization_96 (BatchN  (None, 97, 97, 64)  192         ['conv2d_96[0][0]']
 ormalization)

 activation_96 (Activation)     (None, 97, 97, 64)   0           ['batch_normalizatio
n_96[0][0]']

 max_pooling2d_4 (MaxPooling2D)  (None, 48, 48, 64)  0           ['activation_96[0]
[0]']

 conv2d_97 (Conv2D)             (None, 48, 48, 80)   5120        ['max_pooling2d_4[0]
[0]']

 batch_normalization_97 (BatchN  (None, 48, 48, 80)  240         ['conv2d_97[0][0]']
 ormalization)

 activation_97 (Activation)     (None, 48, 48, 80)   0           ['batch_normalizatio
n_97[0][0]']

 conv2d_98 (Conv2D)             (None, 46, 46, 192)  138240      ['activation_97[0]
[0]']

 batch_normalization_98 (BatchN  (None, 46, 46, 192)  576        ['conv2d_98[0][0]']
 ormalization)

 activation_98 (Activation)     (None, 46, 46, 192)  0           ['batch_normalizatio
n_98[0][0]']

 max_pooling2d_5 (MaxPooling2D)  (None, 22, 22, 192)  0          ['activation_98[0]
[0]']

 conv2d_102 (Conv2D)            (None, 22, 22, 64)   12288       ['max_pooling2d_5[0]
```

```
[0]']

 batch_normalization_102 (Batch  (None, 22, 22, 64)  192         ['conv2d_102[0][0]']
 Normalization)

 activation_102 (Activation)    (None, 22, 22, 64)   0           ['batch_normalizatio
n_102[0][0]']

 conv2d_100 (Conv2D)            (None, 22, 22, 48)   9216        ['max_pooling2d_5[0]
[0]']

 conv2d_103 (Conv2D)            (None, 22, 22, 96)   55296       ['activation_102[0]
[0]']

 batch_normalization_100 (Batch  (None, 22, 22, 48)  144         ['conv2d_100[0][0]']
 Normalization)

 batch_normalization_103 (Batch  (None, 22, 22, 96)  288         ['conv2d_103[0][0]']
 Normalization)

 activation_100 (Activation)    (None, 22, 22, 48)   0           ['batch_normalizatio
n_100[0][0]']

 activation_103 (Activation)    (None, 22, 22, 96)   0           ['batch_normalizatio
n_103[0][0]']

 average_pooling2d_9 (AveragePo  (None, 22, 22, 192)  0          ['max_pooling2d_5[0]
[0]']
 oling2D)

 conv2d_99 (Conv2D)             (None, 22, 22, 64)   12288       ['max_pooling2d_5[0]
[0]']

 conv2d_101 (Conv2D)            (None, 22, 22, 64)   76800       ['activation_100[0]
[0]']

 conv2d_104 (Conv2D)            (None, 22, 22, 96)   82944       ['activation_103[0]
[0]']

 conv2d_105 (Conv2D)            (None, 22, 22, 32)   6144        ['average_pooling2d_
9[0][0]']

 batch_normalization_99 (BatchN  (None, 22, 22, 64)  192         ['conv2d_99[0][0]']
 ormalization)

 batch_normalization_101 (Batch  (None, 22, 22, 64)  192         ['conv2d_101[0][0]']
 Normalization)

 batch_normalization_104 (Batch  (None, 22, 22, 96)  288         ['conv2d_104[0][0]']
 Normalization)

 batch_normalization_105 (Batch  (None, 22, 22, 32)  96          ['conv2d_105[0][0]']
 Normalization)

 activation_99 (Activation)     (None, 22, 22, 64)   0           ['batch_normalizatio
n_99[0][0]']

 activation_101 (Activation)    (None, 22, 22, 64)   0           ['batch_normalizatio
n_101[0][0]']
```

```
 activation_104 (Activation)    (None, 22, 22, 96)   0           ['batch_normalizatio
n_104[0][0]']

 activation_105 (Activation)    (None, 22, 22, 32)   0           ['batch_normalizatio
n_105[0][0]']

 mixed0 (Concatenate)           (None, 22, 22, 256)  0           ['activation_99[0]
[0]',
                                                                  'activation_101[0]
[0]',
                                                                  'activation_104[0]
[0]',
                                                                  'activation_105[0]
[0]']

 conv2d_109 (Conv2D)            (None, 22, 22, 64)   16384       ['mixed0[0][0]']

 batch_normalization_109 (Batch  (None, 22, 22, 64)  192         ['conv2d_109[0][0]']
 Normalization)

 activation_109 (Activation)    (None, 22, 22, 64)   0           ['batch_normalizatio
n_109[0][0]']

 conv2d_107 (Conv2D)            (None, 22, 22, 48)   12288       ['mixed0[0][0]']

 conv2d_110 (Conv2D)            (None, 22, 22, 96)   55296       ['activation_109[0]
[0]']

 batch_normalization_107 (Batch  (None, 22, 22, 48)  144         ['conv2d_107[0][0]']
 Normalization)

 batch_normalization_110 (Batch  (None, 22, 22, 96)  288         ['conv2d_110[0][0]']
 Normalization)

 activation_107 (Activation)    (None, 22, 22, 48)   0           ['batch_normalizatio
n_107[0][0]']

 activation_110 (Activation)    (None, 22, 22, 96)   0           ['batch_normalizatio
n_110[0][0]']

 average_pooling2d_10 (AverageP  (None, 22, 22, 256)  0         ['mixed0[0][0]']
 ooling2D)

 conv2d_106 (Conv2D)            (None, 22, 22, 64)   16384       ['mixed0[0][0]']

 conv2d_108 (Conv2D)            (None, 22, 22, 64)   76800       ['activation_107[0]
[0]']

 conv2d_111 (Conv2D)            (None, 22, 22, 96)   82944       ['activation_110[0]
[0]']

 conv2d_112 (Conv2D)            (None, 22, 22, 64)   16384       ['average_pooling2d_
10[0][0]']

 batch_normalization_106 (Batch  (None, 22, 22, 64)  192         ['conv2d_106[0][0]']
 Normalization)

 batch_normalization_108 (Batch  (None, 22, 22, 64)  192         ['conv2d_108[0][0]']
 Normalization)
```

```
 batch_normalization_111 (Batch  (None, 22, 22, 96)  288         ['conv2d_111[0][0]']
 Normalization)

 batch_normalization_112 (Batch  (None, 22, 22, 64)  192         ['conv2d_112[0][0]']
 Normalization)

 activation_106 (Activation)    (None, 22, 22, 64)   0           ['batch_normalizatio
n_106[0][0]']

 activation_108 (Activation)    (None, 22, 22, 64)   0           ['batch_normalizatio
n_108[0][0]']

 activation_111 (Activation)    (None, 22, 22, 96)   0           ['batch_normalizatio
n_111[0][0]']

 activation_112 (Activation)    (None, 22, 22, 64)   0           ['batch_normalizatio
n_112[0][0]']

 mixed1 (Concatenate)           (None, 22, 22, 288)  0           ['activation_106[0]
[0]',
                                                                  'activation_108[0]
[0]',
                                                                  'activation_111[0]
[0]',
                                                                  'activation_112[0]
[0]']

 conv2d_116 (Conv2D)            (None, 22, 22, 64)   18432       ['mixed1[0][0]']

 batch_normalization_116 (Batch  (None, 22, 22, 64)  192         ['conv2d_116[0][0]']
 Normalization)

 activation_116 (Activation)    (None, 22, 22, 64)   0           ['batch_normalizatio
n_116[0][0]']

 conv2d_114 (Conv2D)            (None, 22, 22, 48)   13824       ['mixed1[0][0]']

 conv2d_117 (Conv2D)            (None, 22, 22, 96)   55296       ['activation_116[0]
[0]']

 batch_normalization_114 (Batch  (None, 22, 22, 48)  144         ['conv2d_114[0][0]']
 Normalization)

 batch_normalization_117 (Batch  (None, 22, 22, 96)  288         ['conv2d_117[0][0]']
 Normalization)

 activation_114 (Activation)    (None, 22, 22, 48)   0           ['batch_normalizatio
n_114[0][0]']

 activation_117 (Activation)    (None, 22, 22, 96)   0           ['batch_normalizatio
n_117[0][0]']

 average_pooling2d_11 (AverageP  (None, 22, 22, 288)  0          ['mixed1[0][0]']
 ooling2D)

 conv2d_113 (Conv2D)            (None, 22, 22, 64)   18432       ['mixed1[0][0]']

 conv2d_115 (Conv2D)            (None, 22, 22, 64)   76800       ['activation_114[0]
[0]']
```

```
 conv2d_118 (Conv2D)            (None, 22, 22, 96)   82944       ['activation_117[0]
[0]']

 conv2d_119 (Conv2D)            (None, 22, 22, 64)   18432       ['average_pooling2d_
11[0][0]']

 batch_normalization_113 (Batch  (None, 22, 22, 64)  192         ['conv2d_113[0][0]']
 Normalization)

 batch_normalization_115 (Batch  (None, 22, 22, 64)  192         ['conv2d_115[0][0]']
 Normalization)

 batch_normalization_118 (Batch  (None, 22, 22, 96)  288         ['conv2d_118[0][0]']
 Normalization)

 batch_normalization_119 (Batch  (None, 22, 22, 64)  192         ['conv2d_119[0][0]']
 Normalization)

 activation_113 (Activation)    (None, 22, 22, 64)   0           ['batch_normalizatio
n_113[0][0]']

 activation_115 (Activation)    (None, 22, 22, 64)   0           ['batch_normalizatio
n_115[0][0]']

 activation_118 (Activation)    (None, 22, 22, 96)   0           ['batch_normalizatio
n_118[0][0]']

 activation_119 (Activation)    (None, 22, 22, 64)   0           ['batch_normalizatio
n_119[0][0]']

 mixed2 (Concatenate)           (None, 22, 22, 288)  0           ['activation_113[0]
[0]',
                                                                  'activation_115[0]
[0]',
                                                                  'activation_118[0]
[0]',
                                                                  'activation_119[0]
[0]']

 conv2d_121 (Conv2D)            (None, 22, 22, 64)   18432       ['mixed2[0][0]']

 batch_normalization_121 (Batch  (None, 22, 22, 64)  192         ['conv2d_121[0][0]']
 Normalization)

 activation_121 (Activation)    (None, 22, 22, 64)   0           ['batch_normalizatio
n_121[0][0]']

 conv2d_122 (Conv2D)            (None, 22, 22, 96)   55296       ['activation_121[0]
[0]']

 batch_normalization_122 (Batch  (None, 22, 22, 96)  288         ['conv2d_122[0][0]']
 Normalization)

 activation_122 (Activation)    (None, 22, 22, 96)   0           ['batch_normalizatio
n_122[0][0]']

 conv2d_120 (Conv2D)            (None, 10, 10, 384)  995328      ['mixed2[0][0]']

 conv2d_123 (Conv2D)            (None, 10, 10, 96)   82944       ['activation_122[0]
[0]']
```

```
 batch_normalization_120 (Batch  (None, 10, 10, 384)  1152       ['conv2d_120[0][0]']
 Normalization)

 batch_normalization_123 (Batch  (None, 10, 10, 96)  288         ['conv2d_123[0][0]']
 Normalization)

 activation_120 (Activation)    (None, 10, 10, 384)  0          ['batch_normalizatio
n_120[0][0]']

 activation_123 (Activation)    (None, 10, 10, 96)   0          ['batch_normalizatio
n_123[0][0]']

 max_pooling2d_6 (MaxPooling2D)  (None, 10, 10, 288)  0         ['mixed2[0][0]']

 mixed3 (Concatenate)           (None, 10, 10, 768)  0          ['activation_120[0]
[0]',
                                                                  'activation_123[0]
[0]',
                                                                  'max_pooling2d_6[0]
[0]']

 conv2d_128 (Conv2D)            (None, 10, 10, 128)  98304      ['mixed3[0][0]']

 batch_normalization_128 (Batch  (None, 10, 10, 128)  384       ['conv2d_128[0][0]']
 Normalization)

 activation_128 (Activation)    (None, 10, 10, 128)  0          ['batch_normalizatio
n_128[0][0]']

 conv2d_129 (Conv2D)            (None, 10, 10, 128)  114688     ['activation_128[0]
[0]']

 batch_normalization_129 (Batch  (None, 10, 10, 128)  384       ['conv2d_129[0][0]']
 Normalization)

 activation_129 (Activation)    (None, 10, 10, 128)  0          ['batch_normalizatio
n_129[0][0]']

 conv2d_125 (Conv2D)            (None, 10, 10, 128)  98304      ['mixed3[0][0]']

 conv2d_130 (Conv2D)            (None, 10, 10, 128)  114688     ['activation_129[0]
[0]']

 batch_normalization_125 (Batch  (None, 10, 10, 128)  384       ['conv2d_125[0][0]']
 Normalization)

 batch_normalization_130 (Batch  (None, 10, 10, 128)  384       ['conv2d_130[0][0]']
 Normalization)

 activation_125 (Activation)    (None, 10, 10, 128)  0          ['batch_normalizatio
n_125[0][0]']

 activation_130 (Activation)    (None, 10, 10, 128)  0          ['batch_normalizatio
n_130[0][0]']

 conv2d_126 (Conv2D)            (None, 10, 10, 128)  114688     ['activation_125[0]
[0]']

 conv2d_131 (Conv2D)            (None, 10, 10, 128)  114688     ['activation_130[0]
```

```
[0]']

 batch_normalization_126 (Batch  (None, 10, 10, 128)  384        ['conv2d_126[0][0]']
 Normalization)

 batch_normalization_131 (Batch  (None, 10, 10, 128)  384        ['conv2d_131[0][0]']
 Normalization)

 activation_126 (Activation)    (None, 10, 10, 128)  0          ['batch_normalizatio
n_126[0][0]']

 activation_131 (Activation)    (None, 10, 10, 128)  0          ['batch_normalizatio
n_131[0][0]']

 average_pooling2d_12 (AverageP  (None, 10, 10, 768)  0         ['mixed3[0][0]']
 ooling2D)

 conv2d_124 (Conv2D)            (None, 10, 10, 192)  147456     ['mixed3[0][0]']

 conv2d_127 (Conv2D)            (None, 10, 10, 192)  172032     ['activation_126[0]
[0]']

 conv2d_132 (Conv2D)            (None, 10, 10, 192)  172032     ['activation_131[0]
[0]']

 conv2d_133 (Conv2D)            (None, 10, 10, 192)  147456     ['average_pooling2d_
12[0][0]']

 batch_normalization_124 (Batch  (None, 10, 10, 192)  576        ['conv2d_124[0][0]']
 Normalization)

 batch_normalization_127 (Batch  (None, 10, 10, 192)  576        ['conv2d_127[0][0]']
 Normalization)

 batch_normalization_132 (Batch  (None, 10, 10, 192)  576        ['conv2d_132[0][0]']
 Normalization)

 batch_normalization_133 (Batch  (None, 10, 10, 192)  576        ['conv2d_133[0][0]']
 Normalization)

 activation_124 (Activation)    (None, 10, 10, 192)  0          ['batch_normalizatio
n_124[0][0]']

 activation_127 (Activation)    (None, 10, 10, 192)  0          ['batch_normalizatio
n_127[0][0]']

 activation_132 (Activation)    (None, 10, 10, 192)  0          ['batch_normalizatio
n_132[0][0]']

 activation_133 (Activation)    (None, 10, 10, 192)  0          ['batch_normalizatio
n_133[0][0]']

 mixed4 (Concatenate)           (None, 10, 10, 768)  0          ['activation_124[0]
[0]',
                                                                 'activation_127[0]
[0]',
                                                                 'activation_132[0]
[0]',
                                                                 'activation_133[0]
[0]']
```

```
 conv2d_138 (Conv2D)            (None, 10, 10, 160)  122880      ['mixed4[0][0]']

 batch_normalization_138 (Batch  (None, 10, 10, 160)  480        ['conv2d_138[0][0]']
 Normalization)

 activation_138 (Activation)    (None, 10, 10, 160)  0          ['batch_normalizatio
n_138[0][0]']

 conv2d_139 (Conv2D)            (None, 10, 10, 160)  179200      ['activation_138[0]
[0]']

 batch_normalization_139 (Batch  (None, 10, 10, 160)  480        ['conv2d_139[0][0]']
 Normalization)

 activation_139 (Activation)    (None, 10, 10, 160)  0          ['batch_normalizatio
n_139[0][0]']

 conv2d_135 (Conv2D)            (None, 10, 10, 160)  122880      ['mixed4[0][0]']

 conv2d_140 (Conv2D)            (None, 10, 10, 160)  179200      ['activation_139[0]
[0]']

 batch_normalization_135 (Batch  (None, 10, 10, 160)  480        ['conv2d_135[0][0]']
 Normalization)

 batch_normalization_140 (Batch  (None, 10, 10, 160)  480        ['conv2d_140[0][0]']
 Normalization)

 activation_135 (Activation)    (None, 10, 10, 160)  0          ['batch_normalizatio
n_135[0][0]']

 activation_140 (Activation)    (None, 10, 10, 160)  0          ['batch_normalizatio
n_140[0][0]']

 conv2d_136 (Conv2D)            (None, 10, 10, 160)  179200      ['activation_135[0]
[0]']

 conv2d_141 (Conv2D)            (None, 10, 10, 160)  179200      ['activation_140[0]
[0]']

 batch_normalization_136 (Batch  (None, 10, 10, 160)  480        ['conv2d_136[0][0]']
 Normalization)

 batch_normalization_141 (Batch  (None, 10, 10, 160)  480        ['conv2d_141[0][0]']
 Normalization)

 activation_136 (Activation)    (None, 10, 10, 160)  0          ['batch_normalizatio
n_136[0][0]']

 activation_141 (Activation)    (None, 10, 10, 160)  0          ['batch_normalizatio
n_141[0][0]']

 average_pooling2d_13 (AverageP  (None, 10, 10, 768)  0         ['mixed4[0][0]']
 ooling2D)

 conv2d_134 (Conv2D)            (None, 10, 10, 192)  147456      ['mixed4[0][0]']

 conv2d_137 (Conv2D)            (None, 10, 10, 192)  215040      ['activation_136[0]
[0]']
```

```
 conv2d_142 (Conv2D)            (None, 10, 10, 192)  215040      ['activation_141[0]
[0]']

 conv2d_143 (Conv2D)            (None, 10, 10, 192)  147456      ['average_pooling2d_
13[0][0]']

 batch_normalization_134 (Batch  (None, 10, 10, 192)  576        ['conv2d_134[0][0]']
 Normalization)

 batch_normalization_137 (Batch  (None, 10, 10, 192)  576        ['conv2d_137[0][0]']
 Normalization)

 batch_normalization_142 (Batch  (None, 10, 10, 192)  576        ['conv2d_142[0][0]']
 Normalization)

 batch_normalization_143 (Batch  (None, 10, 10, 192)  576        ['conv2d_143[0][0]']
 Normalization)

 activation_134 (Activation)    (None, 10, 10, 192)  0           ['batch_normalizatio
n_134[0][0]']

 activation_137 (Activation)    (None, 10, 10, 192)  0           ['batch_normalizatio
n_137[0][0]']

 activation_142 (Activation)    (None, 10, 10, 192)  0           ['batch_normalizatio
n_142[0][0]']

 activation_143 (Activation)    (None, 10, 10, 192)  0           ['batch_normalizatio
n_143[0][0]']

 mixed5 (Concatenate)           (None, 10, 10, 768)  0           ['activation_134[0]
[0]',
                                                                  'activation_137[0]
[0]',
                                                                  'activation_142[0]
[0]',
                                                                  'activation_143[0]
[0]']

 conv2d_148 (Conv2D)            (None, 10, 10, 160)  122880      ['mixed5[0][0]']

 batch_normalization_148 (Batch  (None, 10, 10, 160)  480        ['conv2d_148[0][0]']
 Normalization)

 activation_148 (Activation)    (None, 10, 10, 160)  0           ['batch_normalizatio
n_148[0][0]']

 conv2d_149 (Conv2D)            (None, 10, 10, 160)  179200      ['activation_148[0]
[0]']

 batch_normalization_149 (Batch  (None, 10, 10, 160)  480        ['conv2d_149[0][0]']
 Normalization)

 activation_149 (Activation)    (None, 10, 10, 160)  0           ['batch_normalizatio
n_149[0][0]']

 conv2d_145 (Conv2D)            (None, 10, 10, 160)  122880      ['mixed5[0][0]']

 conv2d_150 (Conv2D)            (None, 10, 10, 160)  179200      ['activation_149[0]
```

```
[0]']

 batch_normalization_145 (Batch  (None, 10, 10, 160)  480        ['conv2d_145[0][0]']
 Normalization)

 batch_normalization_150 (Batch  (None, 10, 10, 160)  480        ['conv2d_150[0][0]']
 Normalization)

 activation_145 (Activation)    (None, 10, 10, 160)  0          ['batch_normalizatio
n_145[0][0]']

 activation_150 (Activation)    (None, 10, 10, 160)  0          ['batch_normalizatio
n_150[0][0]']

 conv2d_146 (Conv2D)            (None, 10, 10, 160)  179200     ['activation_145[0]
[0]']

 conv2d_151 (Conv2D)            (None, 10, 10, 160)  179200     ['activation_150[0]
[0]']

 batch_normalization_146 (Batch  (None, 10, 10, 160)  480        ['conv2d_146[0][0]']
 Normalization)

 batch_normalization_151 (Batch  (None, 10, 10, 160)  480        ['conv2d_151[0][0]']
 Normalization)

 activation_146 (Activation)    (None, 10, 10, 160)  0          ['batch_normalizatio
n_146[0][0]']

 activation_151 (Activation)    (None, 10, 10, 160)  0          ['batch_normalizatio
n_151[0][0]']

 average_pooling2d_14 (AverageP  (None, 10, 10, 768)  0         ['mixed5[0][0]']
 ooling2D)

 conv2d_144 (Conv2D)            (None, 10, 10, 192)  147456     ['mixed5[0][0]']

 conv2d_147 (Conv2D)            (None, 10, 10, 192)  215040     ['activation_146[0]
[0]']

 conv2d_152 (Conv2D)            (None, 10, 10, 192)  215040     ['activation_151[0]
[0]']

 conv2d_153 (Conv2D)            (None, 10, 10, 192)  147456     ['average_pooling2d_
14[0][0]']

 batch_normalization_144 (Batch  (None, 10, 10, 192)  576        ['conv2d_144[0][0]']
 Normalization)

 batch_normalization_147 (Batch  (None, 10, 10, 192)  576        ['conv2d_147[0][0]']
 Normalization)

 batch_normalization_152 (Batch  (None, 10, 10, 192)  576        ['conv2d_152[0][0]']
 Normalization)

 batch_normalization_153 (Batch  (None, 10, 10, 192)  576        ['conv2d_153[0][0]']
 Normalization)

 activation_144 (Activation)    (None, 10, 10, 192)  0          ['batch_normalizatio
n_144[0][0]']
```

```
 activation_147 (Activation)    (None, 10, 10, 192)  0           ['batch_normalizatio
n_147[0][0]']

 activation_152 (Activation)    (None, 10, 10, 192)  0           ['batch_normalizatio
n_152[0][0]']

 activation_153 (Activation)    (None, 10, 10, 192)  0           ['batch_normalizatio
n_153[0][0]']

 mixed6 (Concatenate)           (None, 10, 10, 768)  0           ['activation_144[0]
[0]',
                                                                  'activation_147[0]
[0]',
                                                                  'activation_152[0]
[0]',
                                                                  'activation_153[0]
[0]']

 conv2d_158 (Conv2D)            (None, 10, 10, 192)  147456      ['mixed6[0][0]']

 batch_normalization_158 (Batch  (None, 10, 10, 192)  576        ['conv2d_158[0][0]']
 Normalization)

 activation_158 (Activation)    (None, 10, 10, 192)  0           ['batch_normalizatio
n_158[0][0]']

 conv2d_159 (Conv2D)            (None, 10, 10, 192)  258048      ['activation_158[0]
[0]']

 batch_normalization_159 (Batch  (None, 10, 10, 192)  576        ['conv2d_159[0][0]']
 Normalization)

 activation_159 (Activation)    (None, 10, 10, 192)  0           ['batch_normalizatio
n_159[0][0]']

 conv2d_155 (Conv2D)            (None, 10, 10, 192)  147456      ['mixed6[0][0]']

 conv2d_160 (Conv2D)            (None, 10, 10, 192)  258048      ['activation_159[0]
[0]']

 batch_normalization_155 (Batch  (None, 10, 10, 192)  576        ['conv2d_155[0][0]']
 Normalization)

 batch_normalization_160 (Batch  (None, 10, 10, 192)  576        ['conv2d_160[0][0]']
 Normalization)

 activation_155 (Activation)    (None, 10, 10, 192)  0           ['batch_normalizatio
n_155[0][0]']

 activation_160 (Activation)    (None, 10, 10, 192)  0           ['batch_normalizatio
n_160[0][0]']

 conv2d_156 (Conv2D)            (None, 10, 10, 192)  258048      ['activation_155[0]
[0]']

 conv2d_161 (Conv2D)            (None, 10, 10, 192)  258048      ['activation_160[0]
[0]']

 batch_normalization_156 (Batch  (None, 10, 10, 192)  576        ['conv2d_156[0][0]']
```

```
 Normalization)

 batch_normalization_161 (Batch  (None, 10, 10, 192)  576        ['conv2d_161[0][0]']
 Normalization)

 activation_156 (Activation)    (None, 10, 10, 192)  0          ['batch_normalizatio
n_156[0][0]']

 activation_161 (Activation)    (None, 10, 10, 192)  0          ['batch_normalizatio
n_161[0][0]']

 average_pooling2d_15 (AverageP  (None, 10, 10, 768)  0         ['mixed6[0][0]']
 ooling2D)

 conv2d_154 (Conv2D)            (None, 10, 10, 192)  147456     ['mixed6[0][0]']

 conv2d_157 (Conv2D)            (None, 10, 10, 192)  258048     ['activation_156[0]
[0]']

 conv2d_162 (Conv2D)            (None, 10, 10, 192)  258048     ['activation_161[0]
[0]']

 conv2d_163 (Conv2D)            (None, 10, 10, 192)  147456     ['average_pooling2d_
15[0][0]']

 batch_normalization_154 (Batch  (None, 10, 10, 192)  576        ['conv2d_154[0][0]']
 Normalization)

 batch_normalization_157 (Batch  (None, 10, 10, 192)  576        ['conv2d_157[0][0]']
 Normalization)

 batch_normalization_162 (Batch  (None, 10, 10, 192)  576        ['conv2d_162[0][0]']
 Normalization)

 batch_normalization_163 (Batch  (None, 10, 10, 192)  576        ['conv2d_163[0][0]']
 Normalization)

 activation_154 (Activation)    (None, 10, 10, 192)  0          ['batch_normalizatio
n_154[0][0]']

 activation_157 (Activation)    (None, 10, 10, 192)  0          ['batch_normalizatio
n_157[0][0]']

 activation_162 (Activation)    (None, 10, 10, 192)  0          ['batch_normalizatio
n_162[0][0]']

 activation_163 (Activation)    (None, 10, 10, 192)  0          ['batch_normalizatio
n_163[0][0]']

 mixed7 (Concatenate)           (None, 10, 10, 768)  0          ['activation_154[0]
[0]',
                                                                 'activation_157[0]
[0]',
                                                                 'activation_162[0]
[0]',
                                                                 'activation_163[0]
[0]']

 conv2d_166 (Conv2D)            (None, 10, 10, 192)  147456     ['mixed7[0][0]']
```

```
 batch_normalization_166 (Batch  (None, 10, 10, 192)  576        ['conv2d_166[0][0]']
 Normalization)

 activation_166 (Activation)    (None, 10, 10, 192)  0          ['batch_normalizatio
n_166[0][0]']

 conv2d_167 (Conv2D)            (None, 10, 10, 192)  258048     ['activation_166[0]
[0]']

 batch_normalization_167 (Batch  (None, 10, 10, 192)  576        ['conv2d_167[0][0]']
 Normalization)

 activation_167 (Activation)    (None, 10, 10, 192)  0          ['batch_normalizatio
n_167[0][0]']

 conv2d_164 (Conv2D)            (None, 10, 10, 192)  147456     ['mixed7[0][0]']

 conv2d_168 (Conv2D)            (None, 10, 10, 192)  258048     ['activation_167[0]
[0]']

 batch_normalization_164 (Batch  (None, 10, 10, 192)  576        ['conv2d_164[0][0]']
 Normalization)

 batch_normalization_168 (Batch  (None, 10, 10, 192)  576        ['conv2d_168[0][0]']
 Normalization)

 activation_164 (Activation)    (None, 10, 10, 192)  0          ['batch_normalizatio
n_164[0][0]']

 activation_168 (Activation)    (None, 10, 10, 192)  0          ['batch_normalizatio
n_168[0][0]']

 conv2d_165 (Conv2D)            (None, 4, 4, 320)    552960     ['activation_164[0]
[0]']

 conv2d_169 (Conv2D)            (None, 4, 4, 192)    331776     ['activation_168[0]
[0]']

 batch_normalization_165 (Batch  (None, 4, 4, 320)   960        ['conv2d_165[0][0]']
 Normalization)

 batch_normalization_169 (Batch  (None, 4, 4, 192)   576        ['conv2d_169[0][0]']
 Normalization)

 activation_165 (Activation)    (None, 4, 4, 320)    0          ['batch_normalizatio
n_165[0][0]']

 activation_169 (Activation)    (None, 4, 4, 192)    0          ['batch_normalizatio
n_169[0][0]']

 max_pooling2d_7 (MaxPooling2D)  (None, 4, 4, 768)   0          ['mixed7[0][0]']

 mixed8 (Concatenate)           (None, 4, 4, 1280)   0          ['activation_165[0]
[0]',
                                                                 'activation_169[0]
[0]',
                                                                 'max_pooling2d_7[0]
[0]']

 conv2d_174 (Conv2D)            (None, 4, 4, 448)    573440     ['mixed8[0][0]']
```

```
 batch_normalization_174 (Batch  (None, 4, 4, 448)   1344        ['conv2d_174[0][0]']
 Normalization)

 activation_174 (Activation)    (None, 4, 4, 448)    0           ['batch_normalizatio
n_174[0][0]']

 conv2d_171 (Conv2D)            (None, 4, 4, 384)    491520      ['mixed8[0][0]']

 conv2d_175 (Conv2D)            (None, 4, 4, 384)    1548288     ['activation_174[0]
[0]']

 batch_normalization_171 (Batch  (None, 4, 4, 384)   1152        ['conv2d_171[0][0]']
 Normalization)

 batch_normalization_175 (Batch  (None, 4, 4, 384)   1152        ['conv2d_175[0][0]']
 Normalization)

 activation_171 (Activation)    (None, 4, 4, 384)    0           ['batch_normalizatio
n_171[0][0]']

 activation_175 (Activation)    (None, 4, 4, 384)    0           ['batch_normalizatio
n_175[0][0]']

 conv2d_172 (Conv2D)            (None, 4, 4, 384)    442368      ['activation_171[0]
[0]']

 conv2d_173 (Conv2D)            (None, 4, 4, 384)    442368      ['activation_171[0]
[0]']

 conv2d_176 (Conv2D)            (None, 4, 4, 384)    442368      ['activation_175[0]
[0]']

 conv2d_177 (Conv2D)            (None, 4, 4, 384)    442368      ['activation_175[0]
[0]']

 average_pooling2d_16 (AverageP  (None, 4, 4, 1280)  0           ['mixed8[0][0]']
 ooling2D)

 conv2d_170 (Conv2D)            (None, 4, 4, 320)    409600      ['mixed8[0][0]']

 batch_normalization_172 (Batch  (None, 4, 4, 384)   1152        ['conv2d_172[0][0]']
 Normalization)

 batch_normalization_173 (Batch  (None, 4, 4, 384)   1152        ['conv2d_173[0][0]']
 Normalization)

 batch_normalization_176 (Batch  (None, 4, 4, 384)   1152        ['conv2d_176[0][0]']
 Normalization)

 batch_normalization_177 (Batch  (None, 4, 4, 384)   1152        ['conv2d_177[0][0]']
 Normalization)

 conv2d_178 (Conv2D)            (None, 4, 4, 192)    245760      ['average_pooling2d_
16[0][0]']

 batch_normalization_170 (Batch  (None, 4, 4, 320)   960         ['conv2d_170[0][0]']
 Normalization)

 activation_172 (Activation)    (None, 4, 4, 384)    0           ['batch_normalizatio
```

```
n_172[0][0]']

 activation_173 (Activation)    (None, 4, 4, 384)    0           ['batch_normalizatio
n_173[0][0]']

 activation_176 (Activation)    (None, 4, 4, 384)    0           ['batch_normalizatio
n_176[0][0]']

 activation_177 (Activation)    (None, 4, 4, 384)    0           ['batch_normalizatio
n_177[0][0]']

 batch_normalization_178 (Batch  (None, 4, 4, 192)   576         ['conv2d_178[0][0]']
 Normalization)

 activation_170 (Activation)    (None, 4, 4, 320)    0           ['batch_normalizatio
n_170[0][0]']

 mixed9_0 (Concatenate)         (None, 4, 4, 768)    0           ['activation_172[0]
[0]',
                                                                  'activation_173[0]
[0]']

 concatenate_2 (Concatenate)    (None, 4, 4, 768)    0           ['activation_176[0]
[0]',
                                                                  'activation_177[0]
[0]']

 activation_178 (Activation)    (None, 4, 4, 192)    0           ['batch_normalizatio
n_178[0][0]']

 mixed9 (Concatenate)           (None, 4, 4, 2048)   0           ['activation_170[0]
[0]',
                                                                  'mixed9_0[0][0]',
                                                                  'concatenate_2[0]
[0]',
                                                                  'activation_178[0]
[0]']

 conv2d_183 (Conv2D)            (None, 4, 4, 448)    917504      ['mixed9[0][0]']

 batch_normalization_183 (Batch  (None, 4, 4, 448)   1344        ['conv2d_183[0][0]']
 Normalization)

 activation_183 (Activation)    (None, 4, 4, 448)    0           ['batch_normalizatio
n_183[0][0]']

 conv2d_180 (Conv2D)            (None, 4, 4, 384)    786432      ['mixed9[0][0]']

 conv2d_184 (Conv2D)            (None, 4, 4, 384)    1548288     ['activation_183[0]
[0]']

 batch_normalization_180 (Batch  (None, 4, 4, 384)   1152        ['conv2d_180[0][0]']
 Normalization)

 batch_normalization_184 (Batch  (None, 4, 4, 384)   1152        ['conv2d_184[0][0]']
 Normalization)

 activation_180 (Activation)    (None, 4, 4, 384)    0           ['batch_normalizatio
n_180[0][0]']
```

```
 activation_184 (Activation)    (None, 4, 4, 384)    0           ['batch_normalizatio
n_184[0][0]']

 conv2d_181 (Conv2D)            (None, 4, 4, 384)    442368      ['activation_180[0]
[0]']

 conv2d_182 (Conv2D)            (None, 4, 4, 384)    442368      ['activation_180[0]
[0]']

 conv2d_185 (Conv2D)            (None, 4, 4, 384)    442368      ['activation_184[0]
[0]']

 conv2d_186 (Conv2D)            (None, 4, 4, 384)    442368      ['activation_184[0]
[0]']

 average_pooling2d_17 (AverageP  (None, 4, 4, 2048)  0           ['mixed9[0][0]']
 ooling2D)

 conv2d_179 (Conv2D)            (None, 4, 4, 320)    655360      ['mixed9[0][0]']

 batch_normalization_181 (Batch  (None, 4, 4, 384)   1152        ['conv2d_181[0][0]']
 Normalization)

 batch_normalization_182 (Batch  (None, 4, 4, 384)   1152        ['conv2d_182[0][0]']
 Normalization)

 batch_normalization_185 (Batch  (None, 4, 4, 384)   1152        ['conv2d_185[0][0]']
 Normalization)

 batch_normalization_186 (Batch  (None, 4, 4, 384)   1152        ['conv2d_186[0][0]']
 Normalization)

 conv2d_187 (Conv2D)            (None, 4, 4, 192)    393216      ['average_pooling2d_
17[0][0]']

 batch_normalization_179 (Batch  (None, 4, 4, 320)   960         ['conv2d_179[0][0]']
 Normalization)

 activation_181 (Activation)    (None, 4, 4, 384)    0           ['batch_normalizatio
n_181[0][0]']

 activation_182 (Activation)    (None, 4, 4, 384)    0           ['batch_normalizatio
n_182[0][0]']

 activation_185 (Activation)    (None, 4, 4, 384)    0           ['batch_normalizatio
n_185[0][0]']

 activation_186 (Activation)    (None, 4, 4, 384)    0           ['batch_normalizatio
n_186[0][0]']

 batch_normalization_187 (Batch  (None, 4, 4, 192)   576         ['conv2d_187[0][0]']
 Normalization)

 activation_179 (Activation)    (None, 4, 4, 320)    0           ['batch_normalizatio
n_179[0][0]']

 mixed9_1 (Concatenate)         (None, 4, 4, 768)    0           ['activation_181[0]
[0]',
                                                                  'activation_182[0]
[0]']
```

```
 concatenate_3 (Concatenate)    (None, 4, 4, 768)    0           ['activation_185[0]
[0]',
                                                                  'activation_186[0]
[0]']

 activation_187 (Activation)    (None, 4, 4, 192)    0           ['batch_normalizatio
n_187[0][0]']

 mixed10 (Concatenate)          (None, 4, 4, 2048)   0           ['activation_179[0]
[0]',
                                                                  'mixed9_1[0][0]',
                                                                  'concatenate_3[0]
[0]',
                                                                  'activation_187[0]
[0]']

==================================================================================
==============
Total params: 21,802,784
Trainable params: 11,114,880
Non-trainable params: 10,687,904
__________________________________________________________________________________
______________
```

In [27]:
```
# Get the output layer of the InceptionV3 model
InceptionOutputLayer = inception_v3_model.get_layer('mixed7')

# Print the shape of the output layer
print('Shape of Inception model output:', InceptionOutputLayer.output_shape)

# Assign the output of the InceptionV3 model to a variable
OutputInception = inception_v3_model.output
```

```
Shape of Inception model output: (None, 10, 10, 768)
```

In [28]:
```
from tensorflow.keras.optimizers import RMSprop, Adam, SGD

# Apply Global Average Pooling to the output of the InceptionV3 model
x = layers.GlobalAveragePooling2D()(OutputInception)

# Add a Dense layer with 1024 units and ReLU activation function
x = layers.Dense(1024, activation='relu')(x)

# Add a Dense layer with 29 units and softmax activation function
x = layers.Dense(29, activation='softmax')(x)

# Create a new model with the modified architecture
model = Model(inception_v3_model.input, x)

# Compile the model with specified optimizer, loss function, and metrics
model.compile(
    optimizer=SGD(lr=0.0001, momentum=0.9),
    loss='categorical_crossentropy',
    metrics=['acc']
)
```

```
WARNING:absl:`lr` is deprecated in Keras optimizer, please use `learning_rate` or use
the legacy optimizer, e.g.,tf.keras.optimizers.legacy.SGD.
```

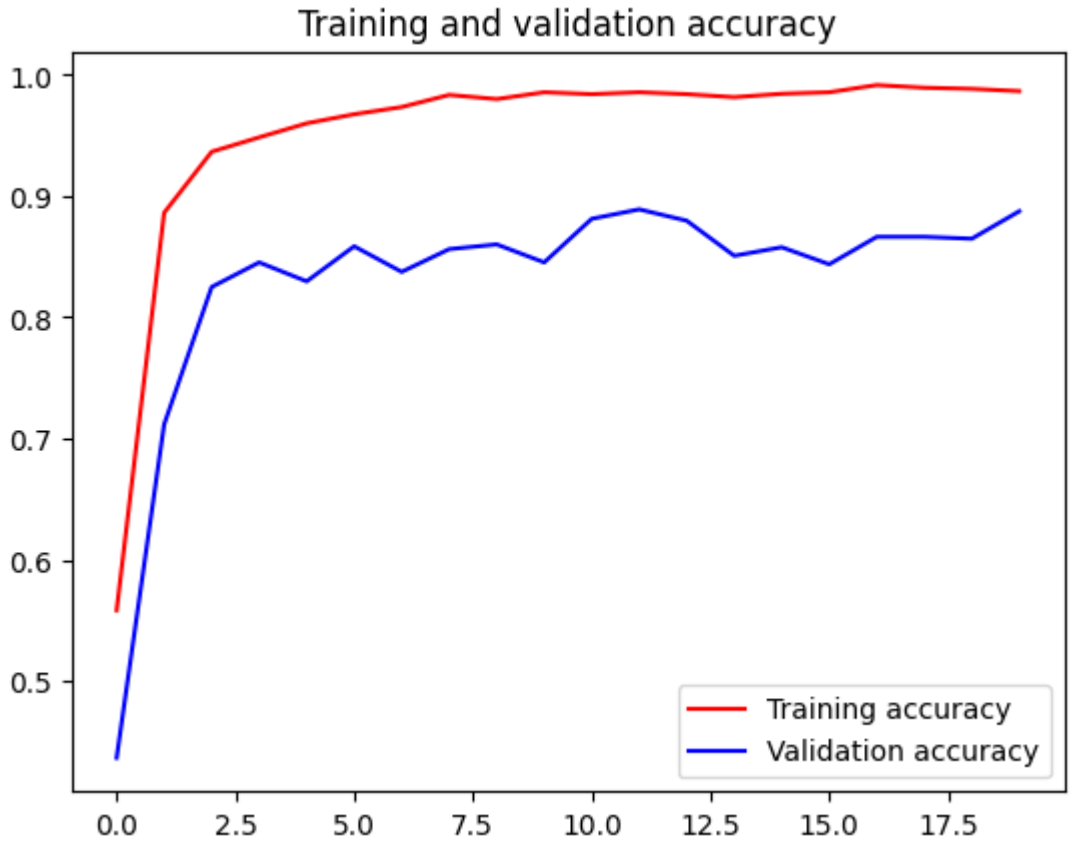
In [29]:
```
ThresholdLoss_ = 0.2
ThresholdAccuracy_ = 0.95

# Custom callback class to stop training when certain conditions are met
class ModelCallback(tf.keras.callbacks.Callback):
    def on_epoch_end(self, epoch, logs={}):
        # Check if validation loss is below the threshold and validation accuracy is a
        if logs.get('val_loss') <= ThresholdLoss_ and logs.get('val_acc') >= Threshold
            print("\nReached", ThresholdAccuracy_ * 100, "accuracy, Stopping!")
            self.model.stop_training = True

# Create an instance of the custom callback
callback = ModelCallback()
```

In [30]:
```
History_ = model.fit_generator(
    Gen_Train_,  # Training data generator
    validation_data=Gen_Validation_,  # Validation data generator
    steps_per_epoch=50,  # Number of batches per epoch during training
    validation_steps=20,  # Number of batches per validation
    epochs=20,  # Number of training epochs
    callbacks=[callback]  # Callback function for monitoring training
)
```

```
C:\Users\Dell\AppData\Local\Temp\ipykernel_6628\337098752.py:1: UserWarning: `Model.f
it_generator` is deprecated and will be removed in a future version. Please use `Mode
l.fit`, which supports generators.
  History_ = model.fit_generator(
```

```
Epoch 1/20
50/50 [==============================] - 149s 3s/step - loss: 1.7339 - acc: 0.5584 -
val_loss: 2.3502 - val_acc: 0.4367
Epoch 2/20
50/50 [==============================] - 160s 3s/step - loss: 0.3897 - acc: 0.8863 -
val_loss: 0.8949 - val_acc: 0.7117
Epoch 3/20
50/50 [==============================] - 173s 3s/step - loss: 0.1970 - acc: 0.9366 -
val_loss: 0.5672 - val_acc: 0.8250
Epoch 4/20
50/50 [==============================] - 159s 3s/step - loss: 0.1638 - acc: 0.9484 -
val_loss: 0.4727 - val_acc: 0.8453
Epoch 5/20
50/50 [==============================] - 167s 3s/step - loss: 0.1261 - acc: 0.9600 -
val_loss: 0.6561 - val_acc: 0.8297
Epoch 6/20
50/50 [==============================] - 158s 3s/step - loss: 0.1132 - acc: 0.9675 -
val_loss: 0.4753 - val_acc: 0.8586
Epoch 7/20
50/50 [==============================] - 160s 3s/step - loss: 0.0824 - acc: 0.9734 -
val_loss: 0.5259 - val_acc: 0.8375
Epoch 8/20
50/50 [==============================] - 158s 3s/step - loss: 0.0553 - acc: 0.9834 -
val_loss: 0.4488 - val_acc: 0.8562
Epoch 9/20
50/50 [==============================] - 158s 3s/step - loss: 0.0593 - acc: 0.9800 -
val_loss: 0.4803 - val_acc: 0.8602
Epoch 10/20
50/50 [==============================] - 155s 3s/step - loss: 0.0483 - acc: 0.9856 -
val_loss: 0.5863 - val_acc: 0.8453
Epoch 11/20
50/50 [==============================] - 170s 3s/step - loss: 0.0510 - acc: 0.9841 -
val_loss: 0.4009 - val_acc: 0.8813
Epoch 12/20
50/50 [==============================] - 171s 3s/step - loss: 0.0433 - acc: 0.9856 -
val_loss: 0.3727 - val_acc: 0.8891
Epoch 13/20
50/50 [==============================] - 157s 3s/step - loss: 0.0497 - acc: 0.9841 -
val_loss: 0.4279 - val_acc: 0.8797
Epoch 14/20
50/50 [==============================] - 163s 3s/step - loss: 0.0516 - acc: 0.9816 -
val_loss: 0.5183 - val_acc: 0.8508
Epoch 15/20
50/50 [==============================] - 177s 4s/step - loss: 0.0425 - acc: 0.9844 -
val_loss: 0.5719 - val_acc: 0.8578
Epoch 16/20
50/50 [==============================] - 158s 3s/step - loss: 0.0425 - acc: 0.9856 -
val_loss: 0.6013 - val_acc: 0.8438
Epoch 17/20
50/50 [==============================] - 158s 3s/step - loss: 0.0302 - acc: 0.9916 -
val_loss: 0.5070 - val_acc: 0.8664
Epoch 18/20
50/50 [==============================] - 160s 3s/step - loss: 0.0355 - acc: 0.9894 -
val_loss: 0.5314 - val_acc: 0.8664
Epoch 19/20
50/50 [==============================] - 157s 3s/step - loss: 0.0343 - acc: 0.9884 -
val_loss: 0.4884 - val_acc: 0.8648
Epoch 20/20
50/50 [==============================] - 156s 3s/step - loss: 0.0455 - acc: 0.9866 -
val_loss: 0.4185 - val_acc: 0.8875
```

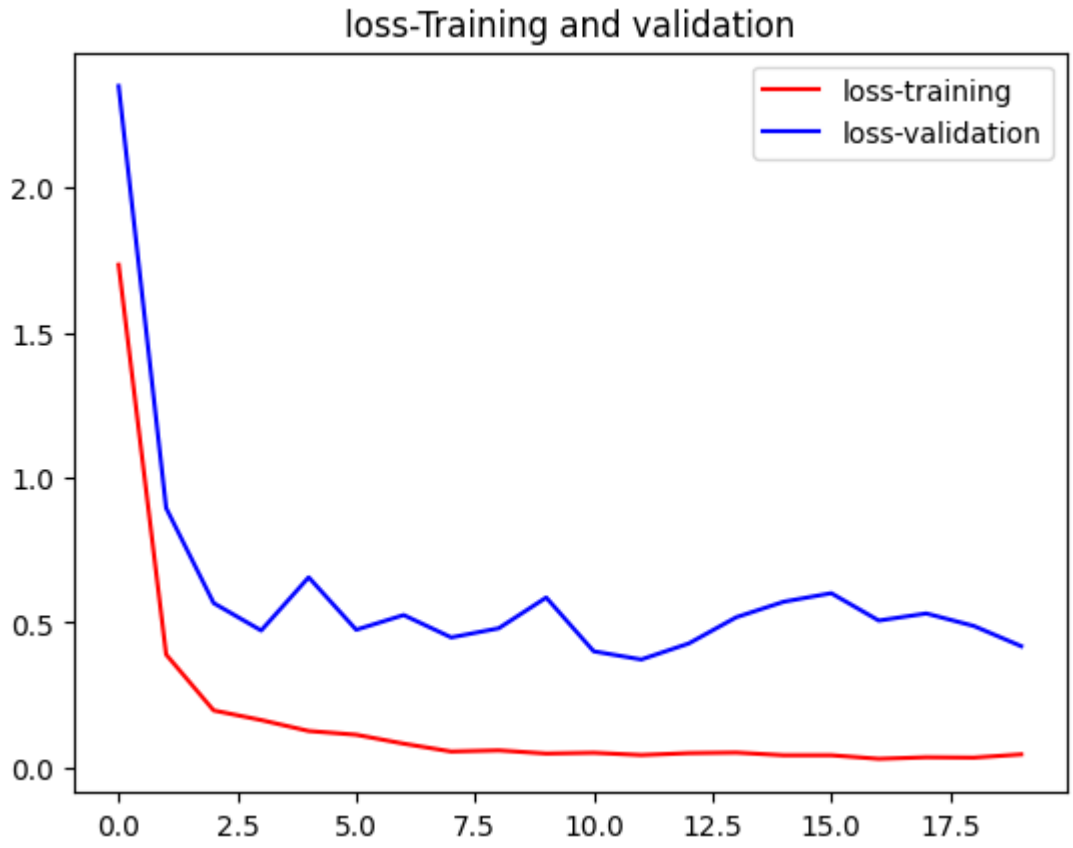
In [31]:
```
import matplotlib.pyplot as plts_

# Extracting the training and validation metrics from the training history
acc = History_.history['acc']
val_acc = History_.history['val_acc']
loss = History_.history['loss']
val_loss = History_.history['val_loss']

epochs = range(len(acc))

# Plotting the training and validation accuracy
plts_.plot(epochs, acc, 'r', label='Training accuracy')  # Plotting training accuracy
plts_.plot(epochs, val_acc, 'b', label='Validation accuracy')  # Plotting validation a
plts_.title('Training and validation accuracy')  # Setting the title of the plot
plts_.legend(loc=0)  # Adding a legend to the plot
plts_.figure()  # Creating a new figure

# Displaying the plot
plts_.show()
```




```
<Figure size 640x480 with 0 Axes>
```

In [32]:
```
plts_.plot(epochs, loss, 'r', label='loss-training')  # Plotting training loss values
plts_.plot(epochs, val_loss, 'b', label='loss-validation')  # Plotting validation loss
plts_.title('loss-Training and validation')  # Setting the title of the plot
plts_.legend(loc=0)  # Adding a legend to the plot
plts_.figure()  # Creating a new figure
```

Out[32]:
```
<Figure size 640x480 with 0 Axes>
```




```
<Figure size 640x480 with 0 Axes>
```

In [33]:
```
NameModel_ = 'models/asl_alphabet_{}.h5'.format(9575)
model.save(NameModel_)
```

In [42]:
```
import cv2
import numpy as nps_
import os
import matplotlib.pyplot as plts_

# Obtaining the list of classes from the training directory and sorting them
Classes_ = os.listdir(Directory_Training_)
Classes_.sort()

# Iterating over the test images in the testing directory
for i, TestImage_ in enumerate(os.listdir(Directory_Testing)):
    # Obtaining the image location
    image_location = Directory_Testing + TestImage_
    # Reading the image using OpenCV
img = cv2.imread(image_location)

    # Resizing the image to the desired size

img = cv2.resize(img, (Size_of_image, Size_of_image))

    # Creating a new figure for displaying the image
plts_.figure()

    # Turning off the axes for the plot
plts_.axis('Off')
```

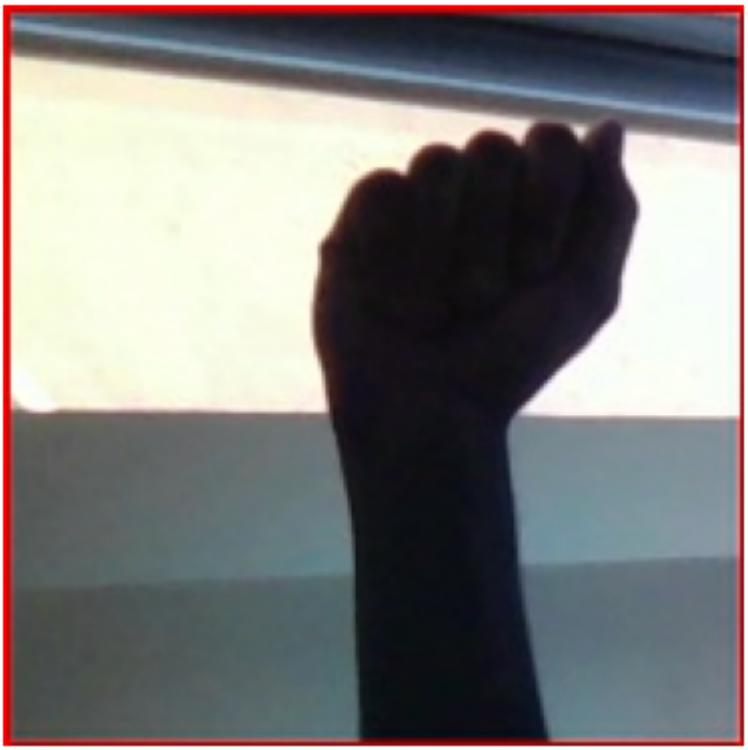
```
    # Displaying the image using imshow
plts_.imshow(img)
```

Out[42]:
```
<matplotlib.image.AxesImage at 0x27c995eeee0>
```

In [43]:
```
import cv2
import numpy as nps_
import os
import matplotlib.pyplot as plts_

# Obtaining the list of classes from the training directory and sorting them
Classes_ = os.listdir(Directory_Training_)
Classes_.sort()

# Iterating over the test images in the testing directory
for i, TestImage_ in enumerate(os.listdir(Directory_Testing)):
    # Obtaining the image location
    image_location = Directory_Testing + TestImage_
    print(image_location)

    # Reading the image using OpenCV
    img = cv2.imread(image_location)

    # Resizing the image to the desired size

    img = cv2.resize(img, (Size_of_image, Size_of_image))

    # Creating a new figure for displaying the image
    plts_.figure()

    # Turning off the axes for the plot
    plts_.axis('Off')

    # Displaying the image using imshow
    plts_.imshow(img)
```

```
    # Converting the image to a numpy array and normalizing its values
    img = nps_.array(img) / 255.

    # Reshaping the image to match the input shape expected by the model
    img = img.reshape((1, Size_of_image, Size_of_image, 3))

    # Standardizing the image using the data generator
    img = Gen_Data_.standardize(img)

    # Making a prediction on the image using the model
    prediction = nps_.array(model.predict(img))

    # Extracting the actual and predicted class labels
    actual = TestImage_.split('_')[0]
    predicted = Classes_[prediction.argmax()]

    # Printing the actual and predicted class labels
    print('Actual_Class {} \n Predicted_Class {}'.format(actual, predicted))

    # Displaying the plotted image
    plts_.show()
```

```
C:/Users/Dell/Desktop/asl_alphabet_test/asl_alphabet_test/A_test.jpg
1/1 [==============================] - 0s 47ms/step
Actual_Class A
 Predicted_Class A
```

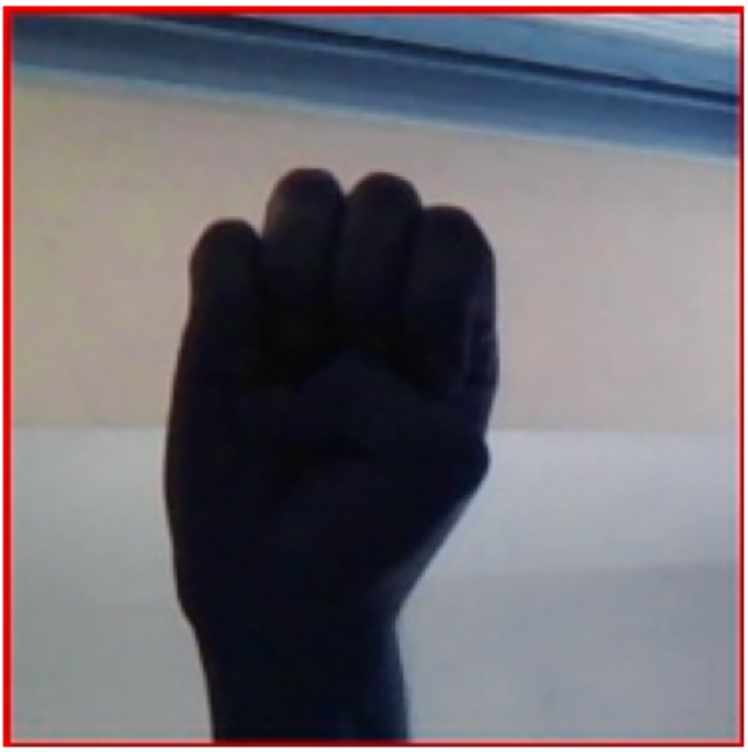


```
C:/Users/Dell/Desktop/asl_alphabet_test/asl_alphabet_test/B_test.jpg
1/1 [==============================] - 0s 44ms/step
Actual_Class B
 Predicted_Class B
```

```
C:/Users/Dell/Desktop/asl_alphabet_test/asl_alphabet_test/C_test.jpg
1/1 [==============================] - 0s 55ms/step
Actual_Class C
 Predicted_Class C
```

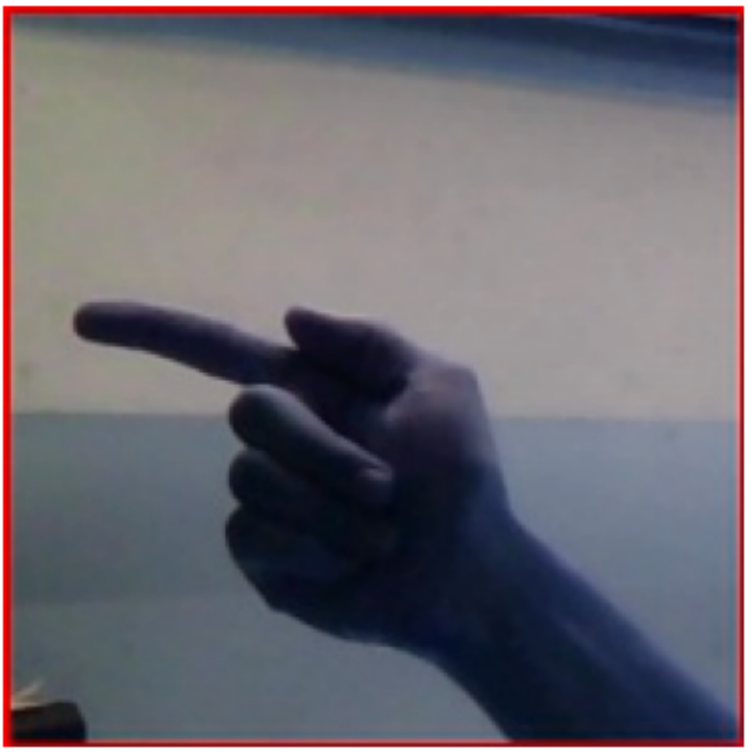
```
C:/Users/Dell/Desktop/asl_alphabet_test/asl_alphabet_test/D_test.jpg
1/1 [==============================] - 0s 52ms/step
Actual_Class D
 Predicted_Class D
```

```
C:/Users/Dell/Desktop/asl_alphabet_test/asl_alphabet_test/E_test.jpg
1/1 [==============================] - 0s 45ms/step
Actual_Class E
 Predicted_Class E
```

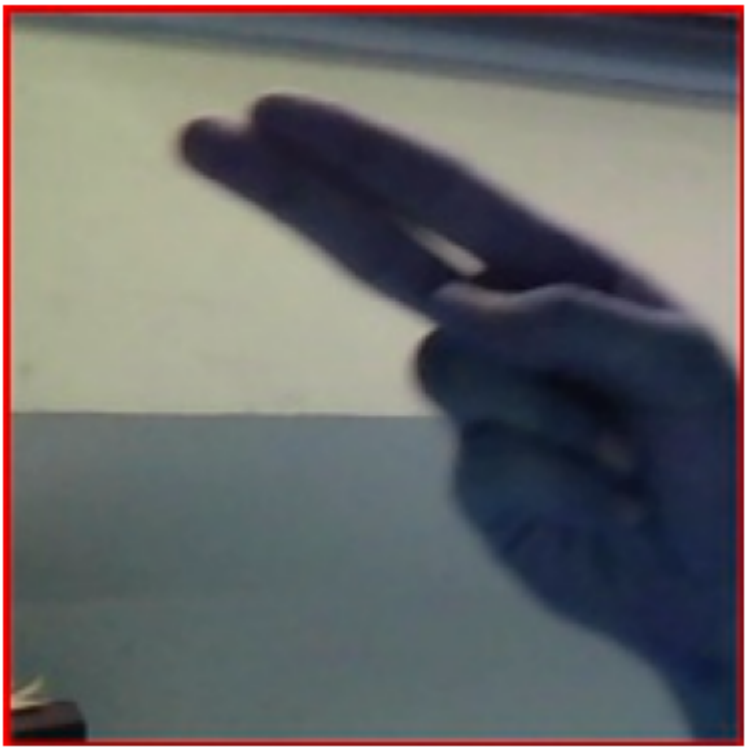


```
C:/Users/Dell/Desktop/asl_alphabet_test/asl_alphabet_test/F_test.jpg
1/1 [==============================] - 0s 44ms/step
Actual_Class F
 Predicted_Class F
```

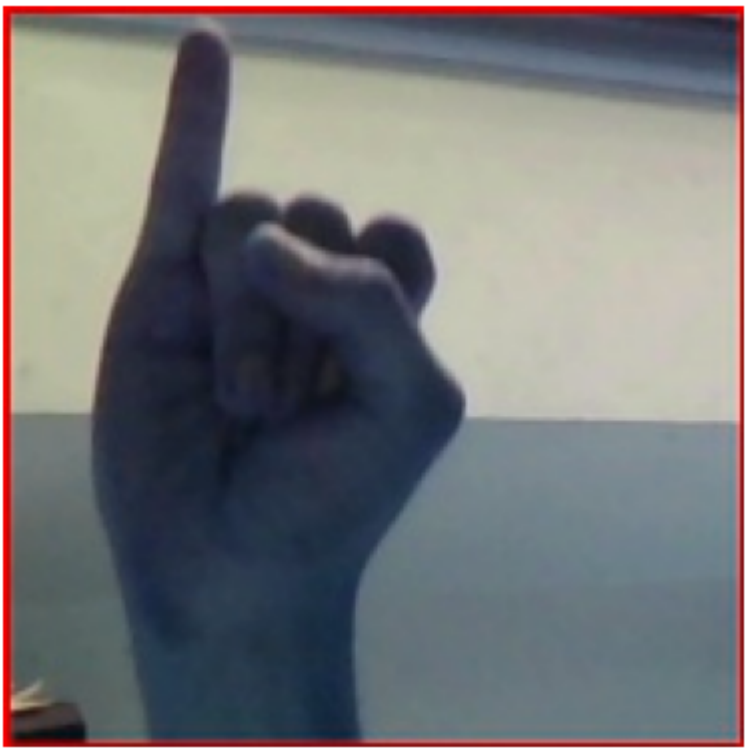
```
C:/Users/Dell/Desktop/asl_alphabet_test/asl_alphabet_test/G_test.jpg
1/1 [==============================] - 0s 53ms/step
Actual_Class G
 Predicted_Class G
```



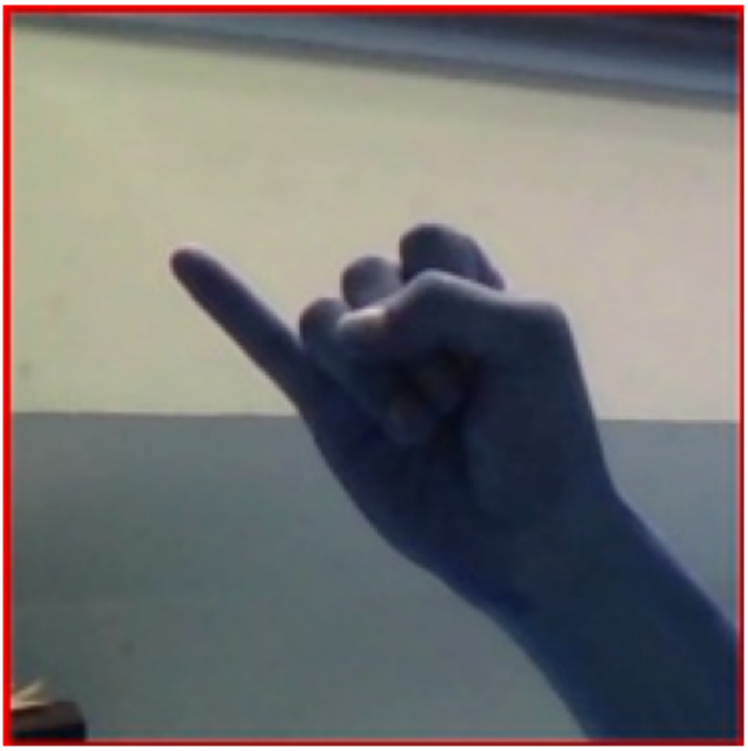
```
C:/Users/Dell/Desktop/asl_alphabet_test/asl_alphabet_test/H_test.jpg
1/1 [==============================] - 0s 65ms/step
Actual_Class H
 Predicted_Class H
```



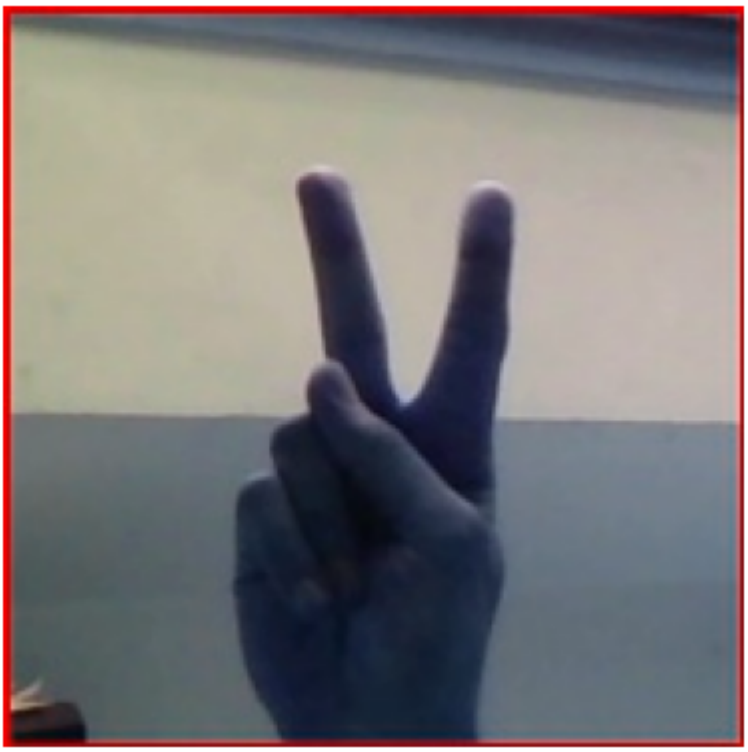
```
C:/Users/Dell/Desktop/asl_alphabet_test/asl_alphabet_test/I_test.jpg
1/1 [==============================] - 0s 65ms/step
Actual_Class I
 Predicted_Class I
```



```
C:/Users/Dell/Desktop/asl_alphabet_test/asl_alphabet_test/J_test.jpg
1/1 [==============================] - 0s 39ms/step
Actual_Class J
 Predicted_Class J
```

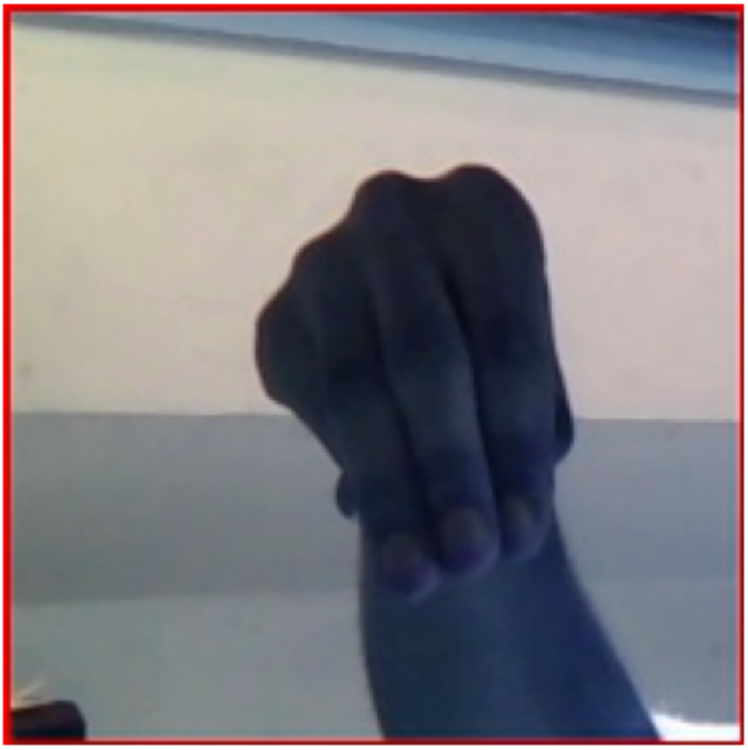


```
C:/Users/Dell/Desktop/asl_alphabet_test/asl_alphabet_test/K_test.jpg
1/1 [==============================] - 0s 51ms/step
Actual_Class K
 Predicted_Class K
```



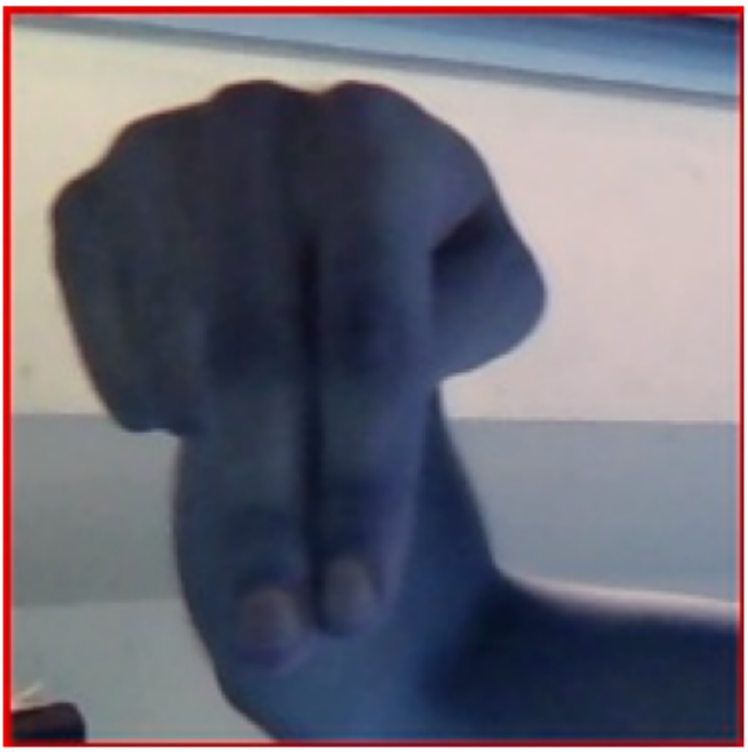
```
C:/Users/Dell/Desktop/asl_alphabet_test/asl_alphabet_test/L_test.jpg
1/1 [==============================] - 0s 49ms/step
Actual_Class L
 Predicted_Class L
```

```
C:/Users/Dell/Desktop/asl_alphabet_test/asl_alphabet_test/M_test.jpg
1/1 [==============================] - 0s 49ms/step
Actual_Class M
 Predicted_Class M
```

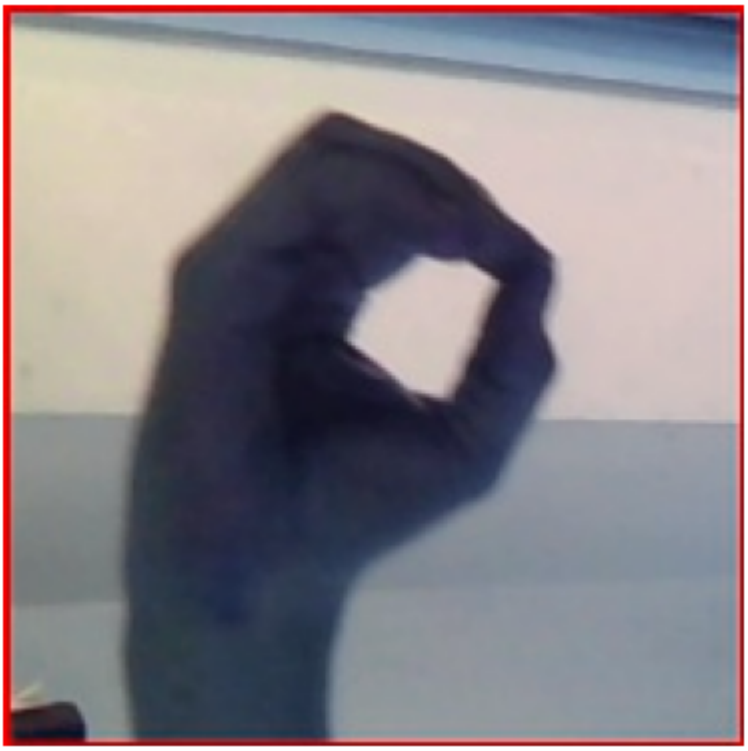


```
C:/Users/Dell/Desktop/asl_alphabet_test/asl_alphabet_test/nothing_test.jpg
1/1 [==============================] - 0s 46ms/step
Actual_Class nothing
 Predicted_Class nothing
```

```
C:/Users/Dell/Desktop/asl_alphabet_test/asl_alphabet_test/N_test.jpg
1/1 [==============================] - 0s 45ms/step
Actual_Class N
 Predicted_Class N
```



```
C:/Users/Dell/Desktop/asl_alphabet_test/asl_alphabet_test/O_test.jpg
1/1 [==============================] - 0s 54ms/step
Actual_Class O
 Predicted_Class O
```



```
C:/Users/Dell/Desktop/asl_alphabet_test/asl_alphabet_test/P_test.jpg
1/1 [==============================] - 0s 57ms/step
Actual_Class P
 Predicted_Class P
```

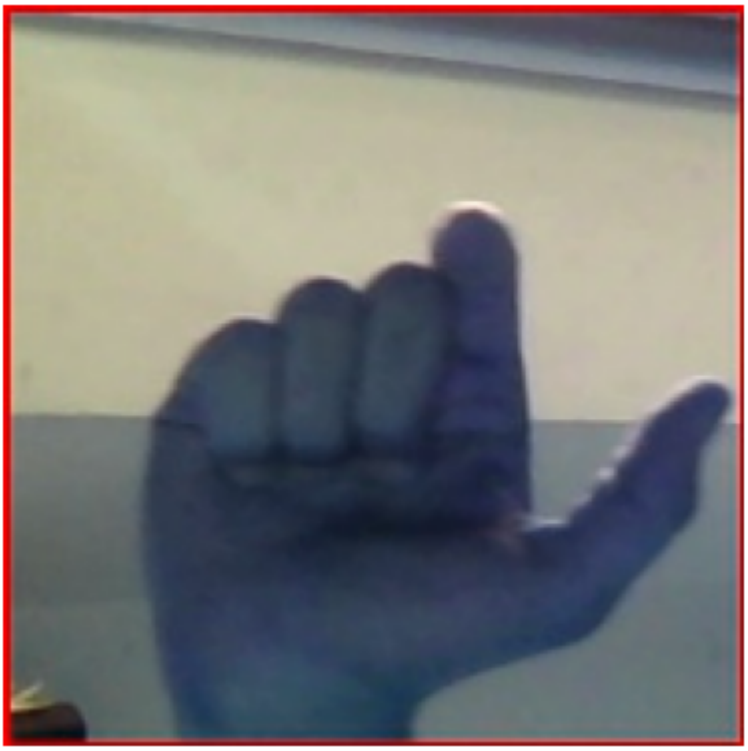
```
C:/Users/Dell/Desktop/asl_alphabet_test/asl_alphabet_test/Q_test.jpg
1/1 [==============================] - 0s 32ms/step
Actual_Class Q
 Predicted_Class Q
```

```
C:/Users/Dell/Desktop/asl_alphabet_test/asl_alphabet_test/R_test.jpg
1/1 [==============================] - 0s 48ms/step
Actual_Class R
 Predicted_Class R
```

```
C:/Users/Dell/Desktop/asl_alphabet_test/asl_alphabet_test/space_test.jpg
1/1 [==============================] - 0s 44ms/step
Actual_Class space
 Predicted_Class space
```

```
C:/Users/Dell/Desktop/asl_alphabet_test/asl_alphabet_test/S_test.jpg
1/1 [==============================] - 0s 45ms/step
Actual_Class S
 Predicted_Class S
```

```
C:/Users/Dell/Desktop/asl_alphabet_test/asl_alphabet_test/T_test.jpg
1/1 [==============================] - 0s 44ms/step
Actual_Class T
 Predicted_Class T
```

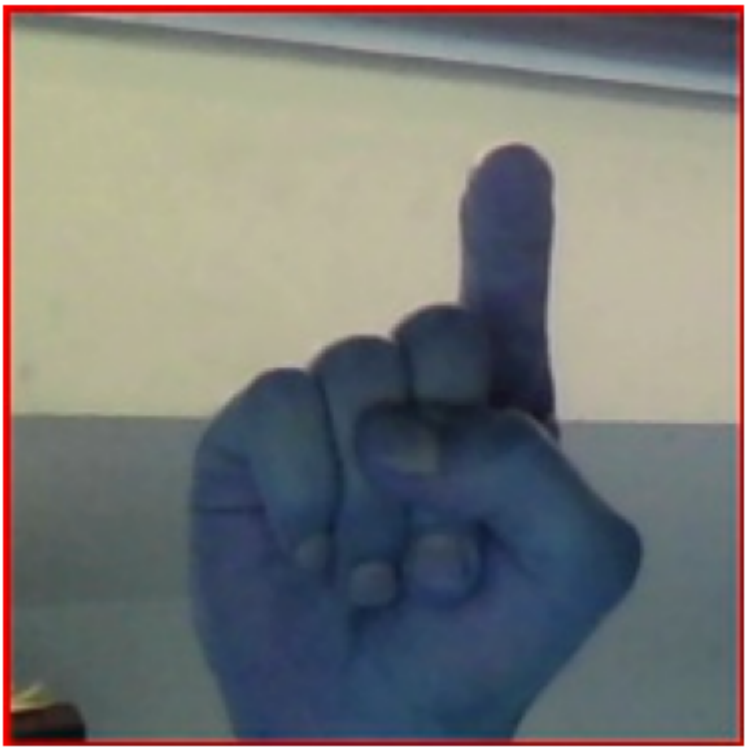


```
C:/Users/Dell/Desktop/asl_alphabet_test/asl_alphabet_test/U_test.jpg
1/1 [==============================] - 0s 50ms/step
Actual_Class U
 Predicted_Class U
```

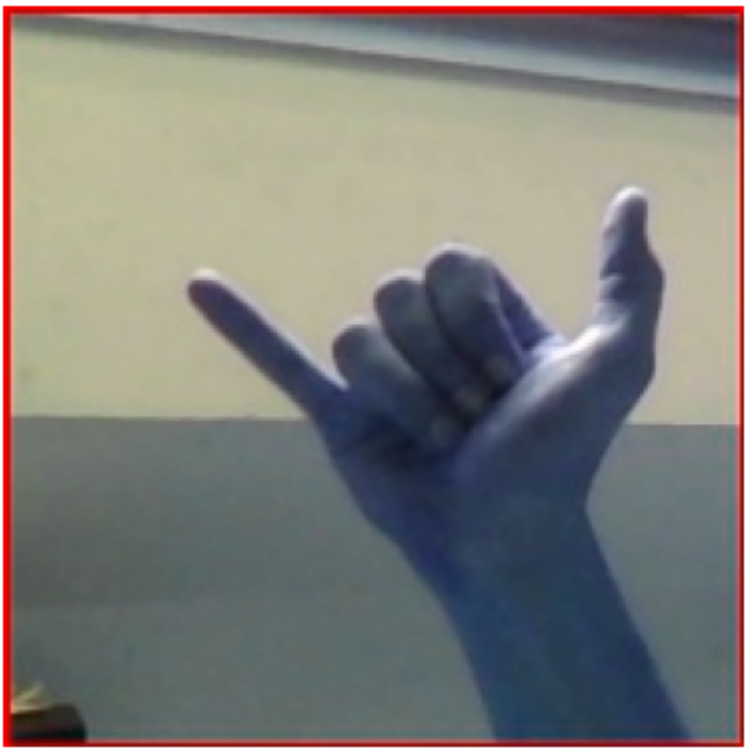
```
C:/Users/Dell/Desktop/asl_alphabet_test/asl_alphabet_test/V_test.jpg
1/1 [==============================] - 0s 49ms/step
Actual_Class V
 Predicted_Class V
```

```
C:/Users/Dell/Desktop/asl_alphabet_test/asl_alphabet_test/W_test.jpg
1/1 [==============================] - 0s 33ms/step
Actual_Class W
 Predicted_Class W
```

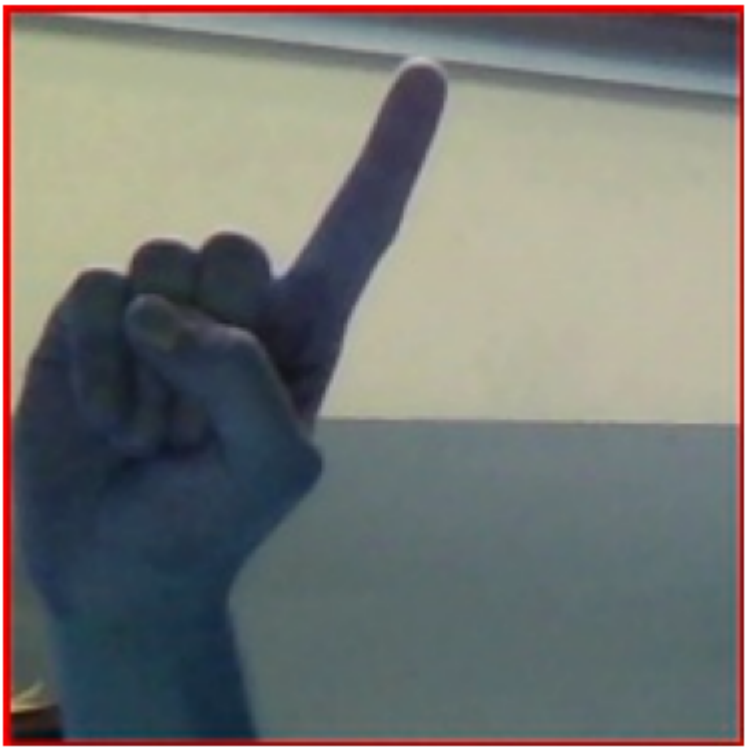
```
C:/Users/Dell/Desktop/asl_alphabet_test/asl_alphabet_test/X_test.jpg
1/1 [==============================] - 0s 44ms/step
Actual_Class X
 Predicted_Class X
```



```
C:/Users/Dell/Desktop/asl_alphabet_test/asl_alphabet_test/Y_test.jpg
1/1 [==============================] - 0s 48ms/step
Actual_Class Y
 Predicted_Class Y
```



```
C:/Users/Dell/Desktop/asl_alphabet_test/asl_alphabet_test/Z_test.jpg
1/1 [==============================] - 0s 47ms/step
Actual_Class Z
 Predicted_Class Z
```



In [40]:
```
# Obtaining the list of test images from the testing directory
ImagesTest_ = os.listdir(Directory_Testing)

# Calculating the total number of test cases
TestCasesTotal_ = len(ImagesTest_)

# Initializing counters for correctly classified and misclassified images
ClassifiedCorrectlyTotal_ = 0
total_misclassified = 0

# Iterating over the test images
for i, TestImage_ in enumerate(ImagesTest_):
    # Obtaining the image location
    image_location = Directory_Testing + TestImage_

    # Reading the image using OpenCV
    img = cv2.imread(image_location)

    # Resizing the image to the desired size
    img = cv2.resize(img, (Size_of_image, Size_of_image))

    # Converting the image to a numpy array and normalizing its values
    img = nps_.array(img) / 255.

    # Reshaping the image to match the input shape expected by the model
    img = img.reshape((1, Size_of_image, Size_of_image, 3))

    # Standardizing the image using the data generator
    img = Gen_Data_.standardize(img)

    # Making a prediction on the image using the model
    prediction = nps_.array(model.predict(img))

    # Extracting the actual and predicted class labels
    actual = TestImage_.split('_')[0]
```

```
    predicted = Classes_[prediction.argmax()]

    # Printing the actual and predicted class labels
    print('Actual class: {} - Predicted class: {}'.format(actual, predicted), end=' ')

    # Checking if the actual and predicted classes match
    if actual == predicted:
        print('PASSED!')
        ClassifiedCorrectlyTotal_ += 1
    else:
        print('FAILED')
        total_misclassified += 1

print("=" * 20)

# Calculating the accuracy and error rate of the test
AccuracyTest_ = (ClassifiedCorrectlyTotal_ / TestCasesTotal_) * 100
ErrorRateTest_ = (total_misclassified / TestCasesTotal_) * 100

# Printing the test metrics
print('Accuracy - Test:', AccuracyTest_)
print('Error rate - Test:', ErrorRateTest_)
print('Misclassified Classes:', total_misclassified)
print('Correctly classified Classes', ClassifiedCorrectlyTotal_)
```

```
1/1 [==============================] - 0s 83ms/step
Actual class: A - Predicted class: A PASSED!
1/1 [==============================] - 0s 51ms/step
Actual class: B - Predicted class: B PASSED!
1/1 [==============================] - 0s 43ms/step
Actual class: C - Predicted class: C PASSED!
1/1 [==============================] - 0s 53ms/step
Actual class: D - Predicted class: D PASSED!
1/1 [==============================] - 0s 51ms/step
Actual class: E - Predicted class: E PASSED!
1/1 [==============================] - 0s 60ms/step
Actual class: F - Predicted class: F PASSED!
1/1 [==============================] - 0s 40ms/step
Actual class: G - Predicted class: G PASSED!
1/1 [==============================] - 0s 53ms/step
Actual class: H - Predicted class: H PASSED!
1/1 [==============================] - 0s 30ms/step
Actual class: I - Predicted class: I PASSED!
1/1 [==============================] - 0s 46ms/step
Actual class: J - Predicted class: J PASSED!
1/1 [==============================] - 0s 28ms/step
Actual class: K - Predicted class: K PASSED!
1/1 [==============================] - 0s 65ms/step
Actual class: L - Predicted class: L PASSED!
1/1 [==============================] - 0s 51ms/step
Actual class: M - Predicted class: M PASSED!
1/1 [==============================] - 0s 50ms/step
Actual class: nothing - Predicted class: nothing PASSED!
1/1 [==============================] - 0s 52ms/step
Actual class: N - Predicted class: N PASSED!
1/1 [==============================] - 0s 45ms/step
Actual class: O - Predicted class: O PASSED!
1/1 [==============================] - 0s 51ms/step
Actual class: P - Predicted class: P PASSED!
1/1 [==============================] - 0s 62ms/step
Actual class: Q - Predicted class: Q PASSED!
1/1 [==============================] - 0s 53ms/step
Actual class: R - Predicted class: R PASSED!
1/1 [==============================] - 0s 51ms/step
Actual class: space - Predicted class: space PASSED!
1/1 [==============================] - 0s 51ms/step
Actual class: S - Predicted class: S PASSED!
1/1 [==============================] - 0s 41ms/step
Actual class: T - Predicted class: T PASSED!
1/1 [==============================] - 0s 49ms/step
Actual class: U - Predicted class: U PASSED!
1/1 [==============================] - 0s 50ms/step
Actual class: V - Predicted class: V PASSED!
1/1 [==============================] - 0s 52ms/step
Actual class: W - Predicted class: W PASSED!
1/1 [==============================] - 0s 46ms/step
Actual class: X - Predicted class: X PASSED!
1/1 [==============================] - 0s 46ms/step
Actual class: Y - Predicted class: Y PASSED!
1/1 [==============================] - 0s 50ms/step
Actual class: Z - Predicted class: Z PASSED!
====================
Accuracy - Test: 100.0
Error rate - Test: 0.0
```

```
Misclassified Classes: 0
Correctly classified Classes 28
```

In [38]:
```
!pip install nbconvert
```

```
Requirement already satisfied: nbconvert in c:\users\dell\anaconda3\lib\site-packages
(6.4.4)
Requirement already satisfied: testpath in c:\users\dell\anaconda3\lib\site-packages
(from nbconvert) (0.6.0)
Requirement already satisfied: nbformat>=4.4 in c:\users\dell\anaconda3\lib\site-pack
ages (from nbconvert) (5.5.0)
Requirement already satisfied: jinja2>=2.4 in c:\users\dell\anaconda3\lib\site-packag
es (from nbconvert) (2.11.3)
Requirement already satisfied: pandocfilters>=1.4.1 in c:\users\dell\anaconda3\lib\si
te-packages (from nbconvert) (1.5.0)
Requirement already satisfied: beautifulsoup4 in c:\users\dell\anaconda3\lib\site-pac
kages (from nbconvert) (4.11.1)
Requirement already satisfied: mistune<2,>=0.8.1 in c:\users\dell\anaconda3\lib\site-
packages (from nbconvert) (0.8.4)
Requirement already satisfied: traitlets>=5.0 in c:\users\dell\anaconda3\lib\site-pac
kages (from nbconvert) (5.1.1)
Requirement already satisfied: entrypoints>=0.2.2 in c:\users\dell\anaconda3\lib\site
-packages (from nbconvert) (0.4)
Requirement already satisfied: nbclient<0.6.0,>=0.5.0 in c:\users\dell\anaconda3\lib
\site-packages (from nbconvert) (0.5.13)
Requirement already satisfied: jupyter-core in c:\users\dell\anaconda3\lib\site-packa
ges (from nbconvert) (4.11.1)
Requirement already satisfied: jupyterlab-pygments in c:\users\dell\anaconda3\lib\sit
e-packages (from nbconvert) (0.1.2)
Requirement already satisfied: defusedxml in c:\users\dell\anaconda3\lib\site-package
s (from nbconvert) (0.7.1)
Requirement already satisfied: pygments>=2.4.1 in c:\users\dell\anaconda3\lib\site-pa
ckages (from nbconvert) (2.11.2)
Requirement already satisfied: bleach in c:\users\dell\anaconda3\lib\site-packages (f
rom nbconvert) (4.1.0)
Requirement already satisfied: MarkupSafe>=0.23 in c:\users\dell\anaconda3\lib\site-p
ackages (from jinja2>=2.4->nbconvert) (2.0.1)
Requirement already satisfied: nest-asyncio in c:\users\dell\anaconda3\lib\site-packa
ges (from nbclient<0.6.0,>=0.5.0->nbconvert) (1.5.5)
Requirement already satisfied: jupyter-client>=6.1.5 in c:\users\dell\anaconda3\lib\s
ite-packages (from nbclient<0.6.0,>=0.5.0->nbconvert) (7.3.4)
Requirement already satisfied: jsonschema>=2.6 in c:\users\dell\anaconda3\lib\site-pa
ckages (from nbformat>=4.4->nbconvert) (4.16.0)
Requirement already satisfied: fastjsonschema in c:\users\dell\anaconda3\lib\site-pac
kages (from nbformat>=4.4->nbconvert) (2.16.2)
Requirement already satisfied: soupsieve>1.2 in c:\users\dell\anaconda3\lib\site-pack
ages (from beautifulsoup4->nbconvert) (2.3.1)
Requirement already satisfied: six>=1.9.0 in c:\users\dell\anaconda3\lib\site-package
s (from bleach->nbconvert) (1.16.0)
Requirement already satisfied: webencodings in c:\users\dell\anaconda3\lib\site-packa
ges (from bleach->nbconvert) (0.5.1)
Requirement already satisfied: packaging in c:\users\dell\anaconda3\lib\site-packages
(from bleach->nbconvert) (21.3)
Requirement already satisfied: pywin32>=1.0 in c:\users\dell\anaconda3\lib\site-packa
ges (from jupyter-core->nbconvert) (302)
Requirement already satisfied: pyrsistent!=0.17.0,!=0.17.1,!=0.17.2,>=0.14.0 in c:\us
ers\dell\anaconda3\lib\site-packages (from jsonschema>=2.6->nbformat>=4.4->nbconvert)
(0.18.0)
Requirement already satisfied: attrs>=17.4.0 in c:\users\dell\anaconda3\lib\site-pack
ages (from jsonschema>=2.6->nbformat>=4.4->nbconvert) (21.4.0)
Requirement already satisfied: tornado>=6.0 in c:\users\dell\anaconda3\lib\site-packa
ges (from jupyter-client>=6.1.5->nbclient<0.6.0,>=0.5.0->nbconvert) (6.1)
Requirement already satisfied: python-dateutil>=2.8.2 in c:\users\dell\anaconda3\lib
\site-packages (from jupyter-client>=6.1.5->nbclient<0.6.0,>=0.5.0->nbconvert) (2.8.
2)
```

```
Requirement already satisfied: pyzmq>=23.0 in c:\users\dell\anaconda3\lib\site-packag
es (from jupyter-client>=6.1.5->nbclient<0.6.0,>=0.5.0->nbconvert) (23.2.0)
Requirement already satisfied: pyparsing!=3.0.5,>=2.0.2 in c:\users\dell\anaconda3\li
b\site-packages (from packaging->bleach->nbconvert) (3.0.9)
WARNING: Ignoring invalid distribution -atplotlib (c:\users\dell\anaconda3\lib\site-p
ackages)
WARNING: Ignoring invalid distribution -atplotlib (c:\users\dell\anaconda3\lib\site-p
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WARNING: Ignoring invalid distribution -atplotlib (c:\users\dell\anaconda3\lib\site-p
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WARNING: Ignoring invalid distribution -atplotlib (c:\users\dell\anaconda3\lib\site-p
ackages)
WARNING: Ignoring invalid distribution -atplotlib (c:\users\dell\anaconda3\lib\site-p
ackages)
```

In [39]:
```
!pip install pyppeteer
```

```
Requirement already satisfied: pyppeteer in c:\users\dell\anaconda3\lib\site-packages
(1.0.2)
Requirement already satisfied: importlib-metadata>=1.4 in c:\users\dell\anaconda3\lib
\site-packages (from pyppeteer) (4.11.3)
Requirement already satisfied: tqdm<5.0.0,>=4.42.1 in c:\users\dell\anaconda3\lib\sit
e-packages (from pyppeteer) (4.64.1)
Requirement already satisfied: pyee<9.0.0,>=8.1.0 in c:\users\dell\anaconda3\lib\site
-packages (from pyppeteer) (8.2.2)
Requirement already satisfied: websockets<11.0,>=10.0 in c:\users\dell\anaconda3\lib
\site-packages (from pyppeteer) (10.4)
Requirement already satisfied: urllib3<2.0.0,>=1.25.8 in c:\users\dell\anaconda3\lib
\site-packages (from pyppeteer) (1.26.11)
Requirement already satisfied: appdirs<2.0.0,>=1.4.3 in c:\users\dell\anaconda3\lib\s
ite-packages (from pyppeteer) (1.4.4)
Requirement already satisfied: certifi>=2021 in c:\users\dell\anaconda3\lib\site-pack
ages (from pyppeteer) (2022.9.14)
Requirement already satisfied: zipp>=0.5 in c:\users\dell\anaconda3\lib\site-packages
(from importlib-metadata>=1.4->pyppeteer) (3.8.0)
Requirement already satisfied: colorama in c:\users\dell\anaconda3\lib\site-packages
(from tqdm<5.0.0,>=4.42.1->pyppeteer) (0.4.5)
WARNING: Ignoring invalid distribution -atplotlib (c:\users\dell\anaconda3\lib\site-p
ackages)
WARNING: Ignoring invalid distribution -atplotlib (c:\users\dell\anaconda3\lib\site-p
ackages)
WARNING: Ignoring invalid distribution -atplotlib (c:\users\dell\anaconda3\lib\site-p
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WARNING: Ignoring invalid distribution -atplotlib (c:\users\dell\anaconda3\lib\site-p
ackages)
WARNING: Ignoring invalid distribution -atplotlib (c:\users\dell\anaconda3\lib\site-p
ackages)
```

In [ ]:
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