```
pip install Augmentor
```

```
Collecting Augmentor
  Downloading Augmentor-0.2.12-py2.py3-none-any.whl (38 kB)
Requirement already satisfied: Pillow>=5.2.0 in /usr/local/lib/python3.10/dist-packages (from Augmentor) (9.4.0)
Requirement already satisfied: tqdm>=4.9.0 in /usr/local/lib/python3.10/dist-packages (from Augmentor) (4.66.2)
Requirement already satisfied: numpy>=1.11.0 in /usr/local/lib/python3.10/dist-packages (from Augmentor) (1.25.2)
Installing collected packages: Augmentor
Successfully installed Augmentor-0.2.12
```

```
from google.colab import drive
import os
import random
import shutil
from tensorflow import keras
from tensorflow.keras import layers
import tensorflow as tf
import glob
import warnings
warnings.filterwarnings("ignore")
from keras.models import Sequential
from keras.layers import Conv2D, MaxPooling2D, Flatten, Dense, Dropout
from keras.applications import VGG16
from keras.applications.vgg16 import VGG16
from keras.models import Model
from PIL import Image
import matplotlib.pyplot as plt
import numpy as np
from tensorflow.keras.preprocessing.image import ImageDataGenerator
from keras.applications.vgg16 import VGG16, decode_predictions
import imgaug.augmenters as iaa
import Augmentor
```

```
drive.mount('/content/drive')
```

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

## Data Augmentation Functions

```
def augment_images(images):
    # Define augmentation sequence
    seq = iaa.Sequential([
        iaa.Fliplr(0.5),  # horizontal flips
        iaa.Affine(rotate=(-10, 10)),  # random rotations
        iaa.GaussianBlur(sigma=(0, 1.0)),  # blur images with a sigma of 0 to 1.0
        iaa.AdditiveGaussianNoise(scale=(0, 0.05*255)),  # add Gaussian noise
        iaa.Multiply((0.8, 1.2), per_channel=0.2),  # multiply brightness
        iaa.ContrastNormalization((0.8, 1.2))  # contrast normalization
    ], random_order=True)  # apply augmenters in random order

    # Augment images
    augmented_images = seq(images=images)
    return augmented_images

# Function to read and augment images from a folder
def read_and_augment_images(folder_path):
    images = []
    for filename in os.listdir(folder_path):
        image_path = os.path.join(folder_path, filename)
        with Image.open(image_path) as img:
            img_array = np.array(img)
            images.append(img_array)
    augmented_images = augment_images(images)
    return augmented_images
```

## Function that deletes all non-jpg images

```
def delete_non_jpeg_images(directory):
    deleted_files = []
    for filename in os.listdir(directory):
        filepath = os.path.join(directory, filename)
        try:
            with Image.open(filepath) as img:
                if img.format != 'JPEG':
                    os.remove(filepath)  # Delete the file
                    print(f"Deleted: {filename}")
                    deleted_files.append(filename)
        except:
            os.remove(filepath)  # Delete the file if unable to determine format
            #print(f"{filename}: Unable to determine format. Deleted.")
            deleted_files.append(filename)
    return deleted_files
```

## Uploading and labeling data from Google Drive

```
data_folder_path = "/content/drive/My Drive/DS340/DS340_Project/Data"

# List of car types
car_types = ['SUV', 'Sedan', 'Pickup_Truck', 'Hatchback', 'Sports_Car']

for car_type in car_types:
    # Define the path to the current car type folder
    car_type_folder_path = os.path.join(data_folder_path, car_type)

    # Check if the car type folder exists
    if os.path.exists(car_type_folder_path):
        # Define the target directory for the current car type
        target_directory = os.path.join("/content", car_type)

        # Create the target directory if it doesn't exist
        if not os.path.exists(target_directory):
            os.makedirs(target_directory)

        # Get the list of non-JPEG files
        non_jpeg_files = delete_non_jpeg_images(car_type_folder_path)

        # Delete non-JPEG files
        for filename in non_jpeg_files:
            filepath = os.path.join(car_type_folder_path, filename)
            os.remove(filepath)

        # List all files in the current car type folder after deletion
        files_after_deletion = os.listdir(car_type_folder_path)

        # Rename and copy files with the car type prefix
        for i, file_name in enumerate(files_after_deletion):
            # Construct the new file name with the car type prefix and index
            new_file_name = f"{car_type}_{i+1}.jpg"

            # Define the current file path and the new file path
            current_file_path = os.path.join(car_type_folder_path, file_name)
            new_file_path = os.path.join(target_directory, new_file_name)

            # Copy the file
            shutil.copy(current_file_path, new_file_path)
```

```
!ls
```

```
drive  Hatchback  Pickup_Truck  sample_data  Sedan  Sports_Car  SUV
```

**Total Number of Files**

SUV: 1,493

Sports_Car: 726

Hatchback: 729

Pickup_Trunk: 1,669

Sedan: 1,222

## Train, validation test directories with cartypes as subdirectories.

```
# Function to move files from one directory to another
def move_files(source_dir, files, destination_dir):
    for file_name in files:
        source_path = os.path.join(source_dir, file_name)
        destination_path = os.path.join(destination_dir, file_name)
        shutil.move(source_path, destination_path)

# List of directories
directories = ['Hatchback', 'Pickup_Truck', 'Sedan', 'Sports_Car', 'SUV']

# Name of the new directories
train_directory = 'train'
validation_directory = 'validation'
test_directory = 'test'

# Create the new directories if they don't exist
for directory in [train_directory, validation_directory, test_directory]:
    if not os.path.exists(directory):
        os.mkdir(directory)

# Loop through each directory
for directory in directories:
    # Create subdirectories in train, validation, and test directories
    train_subdir = os.path.join(train_directory, directory)
    validation_subdir = os.path.join(validation_directory, directory)
    test_subdir = os.path.join(test_directory, directory)
    os.makedirs(train_subdir, exist_ok=True)
    os.makedirs(validation_subdir, exist_ok=True)
    os.makedirs(test_subdir, exist_ok=True)

    # List all files in the current directory
    files = os.listdir(directory)
    random.shuffle(files)  # Shuffle the files randomly

    # Calculate the number of files for train, validation, and test (200 for validation and 200 for test)
    num_validation_files = 200
    num_test_files = 200
    num_train_files = len(files) - num_validation_files - num_test_files

    # Split the files into train, validation, and test
    train_files = files[:num_train_files]
    validation_files = files[num_train_files:num_train_files + num_validation_files]
    test_files = files[num_train_files + num_validation_files:]

    # Move files to the train subdirectory
    move_files(directory, train_files, train_subdir)

    # Move files to the validation subdirectory
    move_files(directory, validation_files, validation_subdir)

    # Move files to the test subdirectory
    move_files(directory, test_files, test_subdir)

print("Files moved successfully!")
```

```
Files moved successfully!
```

```
!ls validation/SUV
```

## Data Augmentation

```
# Data Augmentation for every car

# Hatchback
train_directory = "/content/train/Hatchback"

# Create an Augmentor pipeline
p = Augmentor.Pipeline(train_directory)

# Adding augmentation operations
# Flip horizontally with a probability of 0.5
p.flip_left_right(probability=0.5)
# Example: Rotate by a random angle between -10 and 10 degrees
p.rotate(probability=0.7, max_left_rotation=10, max_right_rotation=10)
# Add more augmentation operations as needed

# Set the number of augmented images you want to generate
p.sample(971)

output_dir = "/content/train/Hatchback/output"
suv_dir = "/content/train/Hatchback"

# Move all files from output to Hatchback
for filename in os.listdir(output_dir):
    src = os.path.join(output_dir, filename)
    dst = os.path.join(suv_dir, filename)
    shutil.move(src, dst)
os.rmdir(output_dir)


# SUV
train_directory = "/content/train/SUV"

p = Augmentor.Pipeline(train_directory)
p.flip_left_right(probability=0.5)
p.rotate(probability=0.7, max_left_rotation=10, max_right_rotation=10)
p.sample(207)

output_dir = "/content/train/SUV/output"
suv_dir = "/content/train/SUV"

for filename in os.listdir(output_dir):
    src = os.path.join(output_dir, filename)
    dst = os.path.join(suv_dir, filename)
    shutil.move(src, dst)
os.rmdir(output_dir)


# Pickup_Truck
train_directory = "/content/train/Pickup_Truck"

p = Augmentor.Pipeline(train_directory)
p.flip_left_right(probability=0.5)
p.rotate(probability=0.7, max_left_rotation=10, max_right_rotation=10)
p.sample(31)

output_dir = "/content/train/Pickup_Truck/output"
suv_dir = "/content/train/Pickup_Truck"
```

```
for filename in os.listdir(output_dir):
    src = os.path.join(output_dir, filename)
    dst = os.path.join(suv_dir, filename)
    shutil.move(src, dst)
os.rmdir(output_dir)


# Sedan
train_directory = "/content/train/Sedan"

p = Augmentor.Pipeline(train_directory)
p.flip_left_right(probability=0.5)
p.rotate(probability=0.7, max_left_rotation=10, max_right_rotation=10)
p.sample(478)

output_dir = "/content/train/Sedan/output"
suv_dir = "/content/train/Sedan"

# Move all files from output to SUV
for filename in os.listdir(output_dir):
    src = os.path.join(output_dir, filename)
    dst = os.path.join(suv_dir, filename)
    shutil.move(src, dst)
os.rmdir(output_dir)


# Sports_Car
train_directory = "/content/train/Sports_Car"

p = Augmentor.Pipeline(train_directory)
p.flip_left_right(probability=0.5)
p.rotate(probability=0.7, max_left_rotation=10, max_right_rotation=10)
p.sample(974)

output_dir = "/content/train/Sports_Car/output"
suv_dir = "/content/train/Sports_Car"

# Move all files from output to SUV
for filename in os.listdir(output_dir):
    src = os.path.join(output_dir, filename)
    dst = os.path.join(suv_dir, filename)
    shutil.move(src, dst)
os.rmdir(output_dir)
```

```
Initialised with 329 image(s) found.
Output directory set to /content/train/Hatchback/output.Processing <PIL.Image.Image image mode=RGB size=341x240 at 0x7F83AC63D8D0>: 100%|██████████| 971/971 [00:15<00:
Initialised with 1087 image(s) found.
Output directory set to /content/train/SUV/output.Processing <PIL.JpegImagePlugin.JpegImageFile image mode=RGB size=260x194 at 0x7F83ADFB3E80>: 100%|██████████| 207/20
Initialised with 1299 image(s) found.
Output directory set to /content/train/Pickup_Truck/output.Processing <PIL.Image.Image image mode=RGB size=116x130 at 0x7F83AC63CE50>: 100%|██████████| 31/31 [00:00<00
Initialised with 822 image(s) found.
Output directory set to /content/train/Sedan/output.Processing <PIL.Image.Image image mode=RGB size=338x202 at 0x7F83AC609BD0>: 100%|██████████| 478/478 [00:05<00:00,
Initialised with 326 image(s) found.
Output directory set to /content/train/Sports_Car/output.Processing <PIL.Image.Image image mode=RGB size=1179x483 at 0x7F83AC6DEFE0>: 100%|██████████| 974/974 [01:20<0
```

All car types have 1300-1330 images in training, 200 in validation, and 200 in testing

## Assigning classes to images in training, validation, and testing set

```
image_size = (180, 180)
batch_size = 32

train_ds = tf.keras.preprocessing.image_dataset_from_directory(
    "/content/train",
    labels='inferred',
    seed=1337,
    image_size=image_size,
    batch_size=batch_size,
)
val_ds = tf.keras.preprocessing.image_dataset_from_directory(
    "/content/validation",
    labels='inferred',
    seed=1337,
    image_size=image_size,
    batch_size=batch_size,
)

test_ds = tf.keras.preprocessing.image_dataset_from_directory(
    "/content/test",
    labels='inferred',
    #subset="testing",
    seed=1337,
    image_size=image_size,
    batch_size=batch_size,
    shuffle=True, # Not really sure what this does
)
```

```
Found 6524 files belonging to 5 classes.
Found 1000 files belonging to 5 classes.
Found 1000 files belonging to 5 classes.
```

## Models

### VGG16 Sequential

```
# (Model 1)

model1 = VGG16(include_top=False, input_shape=(180, 180, 3)) # we'll replace the "top" with our own layers
for layer in model1.layers:
    layer.trainable = False

# Add new classifier layers
flat = layers.Flatten()(model1.layers[-1].output) # connect to last layer of VGG
drop1 = layers.Dropout(0.5)(flat)
cls = layers.Dense(128, activation='relu')(drop1)
drop2 = layers.Dropout(0.5)(cls)
output = layers.Dense(5, activation='softmax')(drop2) #


# Define new model
model1 = Model(inputs=model1.inputs, outputs=output)

# Compile model
model1.compile(optimizer="adam", loss='sparse_categorical_crossentropy', metrics=['accuracy'])
model1.fit(train_ds, epochs=7,validation_data=val_ds)
```

```
Downloading data from https://storage.googleapis.com/tensorflow/keras-applications/vgg16/vgg16_weights_tf_dim_ordering_tf_kernels_notop.h5
58889256/58889256 [==============================] - 2s 0us/step
Epoch 1/7
204/204 [==============================] - 38s 144ms/step - loss: 3.0462 - accuracy: 0.6291 - val_loss: 0.5189 - val_accuracy: 0.8510
Epoch 2/7
204/204 [==============================] - 24s 114ms/step - loss: 0.7210 - accuracy: 0.7511 - val_loss: 0.3364 - val_accuracy: 0.8940
Epoch 3/7
204/204 [==============================] - 25s 119ms/step - loss: 0.5723 - accuracy: 0.8046 - val_loss: 0.3641 - val_accuracy: 0.8910
Epoch 4/7
204/204 [==============================] - 25s 121ms/step - loss: 0.4834 - accuracy: 0.8246 - val_loss: 0.2778 - val_accuracy: 0.9280
Epoch 5/7
204/204 [==============================] - 25s 122ms/step - loss: 0.4340 - accuracy: 0.8509 - val_loss: 0.2855 - val_accuracy: 0.9440
Epoch 6/7
204/204 [==============================] - 26s 124ms/step - loss: 0.3670 - accuracy: 0.8702 - val_loss: 0.2828 - val_accuracy: 0.9350
Epoch 7/7
204/204 [==============================] - 25s 120ms/step - loss: 0.3842 - accuracy: 0.8723 - val_loss: 0.2486 - val_accuracy: 0.9440
<keras.src.callbacks.History at 0x7f83ae89fb20>
```

```
# Model 1 testing set accuracy and loss

loss, accuracy = model1.evaluate(test_ds)
loss = round((loss),2)
accuracy = round((accuracy * 100),2)
print("Test Loss:", loss)
print("Test Accuracy:", accuracy,"%")
```

```
32/32 [==============================] - 4s 101ms/step - loss: 0.1445 - accuracy: 0.9560
Test Loss: 0.14
Test Accuracy: 95.6 %
```

```
# (Model 2)

# Pulling pretrained classes from VGG16
model_vgg16 = VGG16(weights='imagenet', include_top=True)  # Include top layers for classification

# Get the class labels for ImageNet
class_labels = decode_predictions(np.zeros((1, 1000)), top=1000)
class_names = [label[1] for label in class_labels[0]]

# After looking through list of pretrained classes, we only found sports_car and pickup
# Find the indices of 'pickup' and 'sports_car' in class_names
pickup_index = class_names.index('pickup')
sports_car_index = class_names.index('sports_car')

# Create your model based on VGG16
model_base = VGG16(include_top=False, input_shape=(180, 180, 3))

# Freeze the layers of the base model
for layer in model_base.layers:
    layer.trainable = False

# Adding my model to pretrained classes of VGG
flat = layers.Flatten()(model_base.layers[-1].output)
drop1 = layers.Dropout(0.5)(flat)
cls = layers.Dense(128, activation='relu')(drop1)
drop2 = layers.Dropout(0.5)(cls)

# Adjust the number of classes in the output layer
new_class_names = class_names[:pickup_index] + ['Pickup_Truck'] + class_names[pickup_index+1:sports_car_index] + ['Sports_Car'] + class_names[sports_car_index+1:]
output = layers.Dense(len(new_class_names), activation='softmax')(drop2)

# Defining model
model2 = Model(inputs=model_base.inputs, outputs=output)

# Compile the final model
model2.compile(optimizer="adam", loss='sparse_categorical_crossentropy', metrics=['accuracy'])

# Now you can train your final model
model2.fit(train_ds, epochs=7, validation_data=val_ds)
```

```
Downloading data from https://storage.googleapis.com/tensorflow/keras-applications/vgg16/vgg16_weights_tf_dim_ordering_tf_kernels.h5
553467096/553467096 [==============================] - 14s 0us/step
Downloading data from https://storage.googleapis.com/download.tensorflow.org/data/imagenet_class_index.json
35363/35363 [==============================] - 0s 0us/step
Epoch 1/7
204/204 [==============================] - 28s 127ms/step - loss: 1.7423 - accuracy: 0.6960 - val_loss: 0.2497 - val_accuracy: 0.9160
Epoch 2/7
204/204 [==============================] - 26s 124ms/step - loss: 0.5033 - accuracy: 0.8418 - val_loss: 0.1479 - val_accuracy: 0.9690
Epoch 3/7
204/204 [==============================] - 25s 119ms/step - loss: 0.4395 - accuracy: 0.8682 - val_loss: 0.1666 - val_accuracy: 0.9710
Epoch 4/7
204/204 [==============================] - 25s 120ms/step - loss: 0.3261 - accuracy: 0.8968 - val_loss: 0.1609 - val_accuracy: 0.9690
Epoch 5/7
204/204 [==============================] - 25s 123ms/step - loss: 0.3145 - accuracy: 0.9024 - val_loss: 0.1831 - val_accuracy: 0.9680
Epoch 6/7
204/204 [==============================] - 26s 123ms/step - loss: 0.2982 - accuracy: 0.9093 - val_loss: 0.1876 - val_accuracy: 0.9580
Epoch 7/7
204/204 [==============================] - 25s 121ms/step - loss: 0.2402 - accuracy: 0.9250 - val_loss: 0.1629 - val_accuracy: 0.9730
<keras.src.callbacks.History at 0x7f839f613a60>
```

```
# Model 2 testing set accuracy and loss

loss, accuracy = model2.evaluate(test_ds)
loss = round((loss),2)
accuracy = round((accuracy * 100),2)
print("Test Loss:", loss)
print("Test Accuracy:", accuracy,"%")
```

```
32/32 [==============================] - 4s 101ms/step - loss: 0.1015 - accuracy: 0.9730
Test Loss: 0.1
Test Accuracy: 97.3 %
```

## Sequential

```
# (Model 3)

model3 = Sequential()

# Define convolutional layers
model3.add(Conv2D(32, (3, 3), activation='relu', padding='same', input_shape=(180, 180, 3)))
model3.add(Conv2D(32, (3, 3), activation='relu', padding='same'))
model3.add(MaxPooling2D((2, 2)))

model3.add(Conv2D(64, (3, 3), activation='relu', padding='same'))
model3.add(Conv2D(64, (3, 3), activation='relu', padding='same'))
model3.add(MaxPooling2D((2, 2)))

model3.add(Conv2D(128, (3, 3), activation='relu', padding='same'))
model3.add(Conv2D(128, (3, 3), activation='relu', padding='same'))
model3.add(MaxPooling2D((2, 2)))

# Define classification layers
model3.add(Flatten())
model3.add(Dense(128, activation='relu'))
model3.add(Dropout(0.5))
model3.add(Dense(128, activation='relu'))
model3.add(Dropout(0.5))
model3.add(Dense(5, activation='softmax'))

# Compiling Model
model3.compile(loss="sparse_categorical_crossentropy", optimizer="adam", metrics=["accuracy"])
model3.fit(train_ds, epochs=7, validation_data=val_ds)
```

```
Epoch 1/7
204/204 [==============================] - 36s 133ms/step - loss: 2.9791 - accuracy: 0.2115 - val_loss: 1.6089 - val_accuracy: 0.2280
Epoch 2/7
204/204 [==============================] - 22s 106ms/step - loss: 1.6161 - accuracy: 0.2157 - val_loss: 1.6097 - val_accuracy: 0.2030
Epoch 3/7
204/204 [==============================] - 21s 100ms/step - loss: 1.6103 - accuracy: 0.2028 - val_loss: 1.6092 - val_accuracy: 0.2030
Epoch 4/7
204/204 [==============================] - 21s 102ms/step - loss: 1.4747 - accuracy: 0.3529 - val_loss: 1.1354 - val_accuracy: 0.5760
Epoch 5/7
204/204 [==============================] - 23s 108ms/step - loss: 1.0940 - accuracy: 0.5765 - val_loss: 0.7741 - val_accuracy: 0.7340
Epoch 6/7
```

```
204/204 [==============================] - 22s 106ms/step - loss: 0.8208 - accuracy: 0.6864 - val_loss: 0.6576 - val_accuracy: 0.7840
Epoch 7/7
204/204 [==============================] - 22s 108ms/step - loss: 0.6592 - accuracy: 0.7551 - val_loss: 0.4780 - val_accuracy: 0.8320
<keras.src.callbacks.History at 0x7f839db4cd00>
```

```
# Model 3 testing set accuracy and loss

loss, accuracy = model3.evaluate(test_ds)
loss = round((loss),2)
accuracy = round((accuracy * 100),2)
print("Test Loss:", loss)
print("Test Accuracy:", accuracy,"%")
```

```
32/32 [==============================] - 2s 59ms/step - loss: 0.4391 - accuracy: 0.8510
Test Loss: 0.44
Test Accuracy: 85.1 %
```

## Keras Sequential

```
# (Model 4)

input_shape = (180, 180, 3)
model4 = keras.Sequential([
    keras.Input(shape=input_shape),
    layers.Rescaling(1.0 / 255),
    layers.Conv2D(32, kernel_size=(3, 3), activation="relu"),
    layers.MaxPooling2D(pool_size=(2, 2)),
    layers.Conv2D(64, kernel_size=(3, 3), activation="relu"),
    layers.MaxPooling2D(pool_size=(2, 2)),
    layers.Flatten(),
    layers.Dropout(0.5),
    layers.Dense(5, activation="softmax")  # Output layer with 5 neurons and softmax activation
])

# Compiling Model
model4.compile(loss="sparse_categorical_crossentropy", optimizer="adam", metrics=["accuracy"])  # Sparse categorical cross-entropy loss
model4.fit(train_ds, epochs=15, validation_data=val_ds)
```

```
Epoch 1/15
204/204 [==============================] - 19s 80ms/step - loss: 0.8575 - accuracy: 0.6845 - val_loss: 0.5355 - val_accuracy: 0.8160
Epoch 2/15
204/204 [==============================] - 18s 88ms/step - loss: 0.2925 - accuracy: 0.9016 - val_loss: 0.4628 - val_accuracy: 0.8570
Epoch 3/15
204/204 [==============================] - 16s 76ms/step - loss: 0.1200 - accuracy: 0.9611 - val_loss: 0.4764 - val_accuracy: 0.8840
Epoch 4/15
204/204 [==============================] - 15s 74ms/step - loss: 0.0769 - accuracy: 0.9775 - val_loss: 0.5138 - val_accuracy: 0.8900
Epoch 5/15
204/204 [==============================] - 16s 75ms/step - loss: 0.0494 - accuracy: 0.9857 - val_loss: 0.6306 - val_accuracy: 0.8990
Epoch 6/15
204/204 [==============================] - 18s 83ms/step - loss: 0.0281 - accuracy: 0.9906 - val_loss: 0.8758 - val_accuracy: 0.8760
Epoch 7/15
204/204 [==============================] - 16s 75ms/step - loss: 0.0290 - accuracy: 0.9896 - val_loss: 0.7406 - val_accuracy: 0.8930
Epoch 8/15
204/204 [==============================] - 16s 77ms/step - loss: 0.0232 - accuracy: 0.9926 - val_loss: 0.6775 - val_accuracy: 0.8880
Epoch 9/15
204/204 [==============================] - 18s 87ms/step - loss: 0.0199 - accuracy: 0.9940 - val_loss: 0.7234 - val_accuracy: 0.8930
Epoch 10/15
```

```
204/204 [==============================] - 16s 76ms/step - loss: 0.0162 - accuracy: 0.9952 - val_loss: 0.8081 - val_accuracy: 0.8750
Epoch 11/15
204/204 [==============================] - 16s 76ms/step - loss: 0.0247 - accuracy: 0.9916 - val_loss: 1.0250 - val_accuracy: 0.8790
Epoch 12/15
204/204 [==============================] - 16s 78ms/step - loss: 0.0215 - accuracy: 0.9925 - val_loss: 0.9256 - val_accuracy: 0.8830
Epoch 13/15
204/204 [==============================] - 16s 75ms/step - loss: 0.0272 - accuracy: 0.9911 - val_loss: 0.8375 - val_accuracy: 0.8970
Epoch 14/15
204/204 [==============================] - 17s 81ms/step - loss: 0.0189 - accuracy: 0.9937 - val_loss: 0.8630 - val_accuracy: 0.8990
Epoch 15/15
204/204 [==============================] - 16s 75ms/step - loss: 0.0206 - accuracy: 0.9940 - val_loss: 0.9216 - val_accuracy: 0.8870
<keras.src.callbacks.History at 0x7f839c75d960>
```

```
# Model 4 testing set accuracy and loss

loss, accuracy = model4.evaluate(test_ds)
loss = round((loss),2)
accuracy = round((accuracy * 100),2)
print("Test Loss:", loss)
print("Test Accuracy:", accuracy,"%")
```

```
32/32 [==============================] - 2s 54ms/step - loss: 0.6424 - accuracy: 0.9150
Test Loss: 0.64
Test Accuracy: 91.5 %
```

```
# (Model 5)
# Same as model 3 but with a deeper architecture

input_shape = (180,180,3)

model5 = keras.Sequential(
    [
        keras.Input(shape=input_shape),
        layers.Rescaling(1.0 / 255),
        layers.Conv2D(32, kernel_size=(3, 3), activation="relu"),
        layers.MaxPooling2D(pool_size=(2, 2)),
        layers.Conv2D(64, kernel_size=(3, 3), activation="relu"),
        layers.MaxPooling2D(pool_size=(2, 2)),
        # More convolutional & pooling layers
        layers.Conv2D(128, kernel_size=(3, 3), activation="relu"),
        layers.MaxPooling2D(pool_size=(2, 2)),
        layers.Conv2D(256, kernel_size=(3, 3), activation="relu"),
        layers.MaxPooling2D(pool_size=(2, 2)),
        layers.Conv2D(512, kernel_size=(3, 3), activation="relu"),
        layers.MaxPooling2D(pool_size=(2, 2)),
        layers.Flatten(),
        layers.Dropout(0.5),
        layers.Dense(5, activation="softmax"),
    ]
)

# Compiling Model
model5.compile(loss="sparse_categorical_crossentropy", optimizer="adam", metrics=["accuracy"])
model5.fit(train_ds, epochs=15, validation_data=val_ds)
```

```
Epoch 1/15
204/204 [==============================] - 22s 90ms/step - loss: 1.1809 - accuracy: 0.5110 - val_loss: 0.8899 - val_accuracy: 0.6730
Epoch 2/15
```

```
204/204 [==============================] - 18s 85ms/step - loss: 0.6996 - accuracy: 0.7405 - val_loss: 0.6738 - val_accuracy: 0.7700
Epoch 3/15
204/204 [==============================] - 18s 83ms/step - loss: 0.4368 - accuracy: 0.8437 - val_loss: 0.4112 - val_accuracy: 0.8530
Epoch 4/15
204/204 [==============================] - 16s 78ms/step - loss: 0.3117 - accuracy: 0.8935 - val_loss: 0.3845 - val_accuracy: 0.8850
Epoch 5/15
204/204 [==============================] - 19s 90ms/step - loss: 0.2010 - accuracy: 0.9303 - val_loss: 0.3448 - val_accuracy: 0.9120
Epoch 6/15
204/204 [==============================] - 16s 78ms/step - loss: 0.1611 - accuracy: 0.9421 - val_loss: 0.4085 - val_accuracy: 0.9200
Epoch 7/15
204/204 [==============================] - 17s 82ms/step - loss: 0.1074 - accuracy: 0.9634 - val_loss: 0.3199 - val_accuracy: 0.9160
Epoch 8/15
204/204 [==============================] - 16s 78ms/step - loss: 0.0841 - accuracy: 0.9706 - val_loss: 0.3753 - val_accuracy: 0.9320
Epoch 9/15
204/204 [==============================] - 16s 77ms/step - loss: 0.0816 - accuracy: 0.9704 - val_loss: 0.4416 - val_accuracy: 0.9250
Epoch 10/15
204/204 [==============================] - 19s 90ms/step - loss: 0.0543 - accuracy: 0.9795 - val_loss: 0.4964 - val_accuracy: 0.9210
Epoch 11/15
204/204 [==============================] - 17s 82ms/step - loss: 0.0633 - accuracy: 0.9801 - val_loss: 0.4597 - val_accuracy: 0.9260
Epoch 12/15
204/204 [==============================] - 19s 91ms/step - loss: 0.0598 - accuracy: 0.9788 - val_loss: 0.4351 - val_accuracy: 0.9310
Epoch 13/15
204/204 [==============================] - 17s 81ms/step - loss: 0.0522 - accuracy: 0.9816 - val_loss: 0.5093 - val_accuracy: 0.9230
Epoch 14/15
204/204 [==============================] - 16s 79ms/step - loss: 0.0479 - accuracy: 0.9841 - val_loss: 0.4279 - val_accuracy: 0.9300
Epoch 15/15
204/204 [==============================] - 16s 78ms/step - loss: 0.0428 - accuracy: 0.9842 - val_loss: 0.5056 - val_accuracy: 0.9280
<keras.src.callbacks.History at 0x7f839c6be530>
```

```
# Model 5 testing set accuracy and loss

loss, accuracy = model5.evaluate(test_ds)
loss = round((loss),2)
accuracy = round((accuracy * 100),2)
print("Test Loss:", loss)
print("Test Accuracy:", accuracy,"%")
```

```
32/32 [==============================] - 2s 57ms/step - loss: 0.3639 - accuracy: 0.9420
Test Loss: 0.36
Test Accuracy: 94.2 %
```

Start coding or generate with AI.

Start coding or generate with AI.

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Start coding or generate with AI.

Start coding or generate with AI.

Start coding or generate with AI.

## Passing through external image to test model

### Using model with highest accuracy and lowest loss (Model 2)

### Images are not in any set (train, validation, test)

```
# Function to preprocess the image
def predict_image(model, image_path, target_size, class_names):
    # Preprocess the image
    img = preprocess_image(image_path, target_size)
    # Make predictions using the model
    predictions = model.predict(img)
    # Get the predicted class index
    predicted_class_index = np.argmax(predictions[0])
    # Get the class label
    predicted_class = class_names[predicted_class_index]
    return predicted_class
```

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    # Get the class label
    predicted_class = class_names[predicted_class_index]
    return predicted_class

# Path to the uploaded image
uploaded_image_path = "McLaren_Sports.jpg"

# Predict the class of the uploaded image
predicted_class = predict_image(model2, uploaded_image_path, target_size, class_names)

# Print the predicted class
print("Predicted Class:", predicted_class)

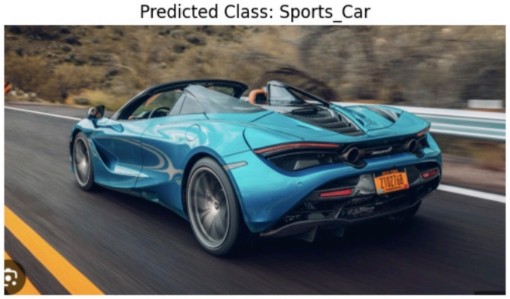
# Optionally, you can visualize the uploaded image
img = Image.open(uploaded_image_path)
plt.imshow(img)
plt.axis('off')
plt.title(f"Predicted Class: {predicted_class}")
plt.show()


# Second Test
uploaded_image_path2 = "Hatchback_17.jpg"
```

```python
# Second Test
uploaded_image_path2 = "Hatchback_17.jpg"

# Predict the class of the uploaded image
predicted_class2 = predict_image(model2, uploaded_image_path2, target_size, class_names)

# Print the predicted class
print("Predicted Class:", predicted_class2)

# Optionally, you can visualize the uploaded image
img = Image.open(uploaded_image_path2)
plt.imshow(img)
plt.axis('off')
plt.title(f"Predicted Class: {predicted_class2}")
plt.show()


# Third Test
uploaded_image_path3 = "GMC_Pickup.jpg"

# Predict the class of the uploaded image
predicted_class3 = predict_image(model2, uploaded_image_path3, target_size, class_names)

# Print the predicted class
print("Predicted Class:", predicted_class3)

# Optionally, you can visualize the uploaded image
img = Image.open(uploaded_image_path3)
plt.imshow(img)
plt.axis('off')
plt.title(f"Predicted Class: {predicted_class3}")
plt.show()
```

```
Predicted Class: Sports_Car
```

Predicted Class: Sports_Car



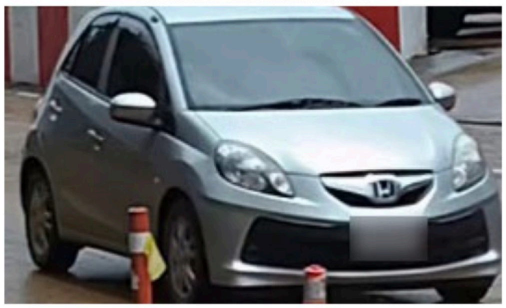
```
1/1 [==============================] - 0s 40ms/step
```

```
1/1 [==============================] - 0s 29ms/step
Predicted Class: Sports_Car
```

Predicted Class: Sports_Car

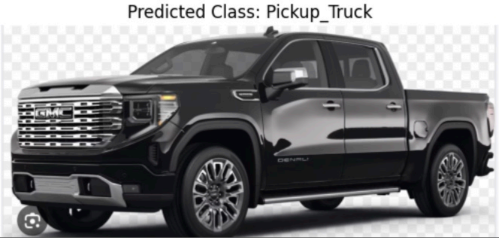
```
1/1 [==============================] - 0s 40ms/step
Predicted Class: Hatchback
```

Predicted Class: Hatchback



```
1/1 [==============================] - 0s 44ms/step
Predicted Class: Pickup_Truck
```

Predicted Class: Pickup_Truck



Connected to Python 3 Google Compute Engine backend (GPU)