```
!pip install keras==2.10.0
!pip install tensorflow==2.10.0
!pip install h5py==3.7.0
```

```
Requirement already satisfied: keras==2.10.0 in /usr/local/lib/python3.10/dist-packages (2.10.0)
Requirement already satisfied: tensorflow==2.10.0 in /usr/local/lib/python3.10/dist-packages (2.10.0)
Requirement already satisfied: absl-py>=1.0.0 in /usr/local/lib/python3.10/dist-packages (from tensorflow==2.10.0) (1.4.0)
Requirement already satisfied: astunparse>=1.6.0 in /usr/local/lib/python3.10/dist-packages (from tensorflow==2.10.0) (1.6.3)
Requirement already satisfied: flatbuffers>=2.0 in /usr/local/lib/python3.10/dist-packages (from tensorflow==2.10.0) (23.5.26)
Requirement already satisfied: gast<=0.4.0,>=0.2.1 in /usr/local/lib/python3.10/dist-packages (from tensorflow==2.10.0) (0.4.0)
Requirement already satisfied: google-pasta>=0.1.1 in /usr/local/lib/python3.10/dist-packages (from tensorflow==2.10.0) (0.2.0)
Requirement already satisfied: grpcio<2.0,>=1.24.3 in /usr/local/lib/python3.10/dist-packages (from tensorflow==2.10.0) (1.56.0)
Requirement already satisfied: h5py>=2.9.0 in /usr/local/lib/python3.10/dist-packages (from tensorflow==2.10.0) (3.7.0)
Requirement already satisfied: keras<2.11,>=2.10.0 in /usr/local/lib/python3.10/dist-packages (from tensorflow==2.10.0) (2.10.0)
Requirement already satisfied: keras-preprocessing>=1.1.1 in /usr/local/lib/python3.10/dist-packages (from tensorflow==2.10.0) (1.1
Requirement already satisfied: libclang>=13.0.0 in /usr/local/lib/python3.10/dist-packages (from tensorflow==2.10.0) (16.0.6)
Requirement already satisfied: numpy>=1.20 in /usr/local/lib/python3.10/dist-packages (from tensorflow==2.10.0) (1.22.4)
Requirement already satisfied: opt-einsum>=2.3.2 in /usr/local/lib/python3.10/dist-packages (from tensorflow==2.10.0) (3.3.0)
Requirement already satisfied: packaging in /usr/local/lib/python3.10/dist-packages (from tensorflow==2.10.0) (23.1)
Requirement already satisfied: protobuf<3.20,>=3.9.2 in /usr/local/lib/python3.10/dist-packages (from tensorflow==2.10.0) (3.19.6)
Requirement already satisfied: setuptools in /usr/local/lib/python3.10/dist-packages (from tensorflow==2.10.0) (67.7.2)
Requirement already satisfied: six>=1.12.0 in /usr/local/lib/python3.10/dist-packages (from tensorflow==2.10.0) (1.16.0)
Requirement already satisfied: tensorboard<2.11,>=2.10 in /usr/local/lib/python3.10/dist-packages (from tensorflow==2.10.0) (2.10.1
Requirement already satisfied: tensorflow-io-gcs-filesystem>=0.23.1 in /usr/local/lib/python3.10/dist-packages (from tensorflow==2.
Requirement already satisfied: tensorflow-estimator<2.11,>=2.10.0 in /usr/local/lib/python3.10/dist-packages (from tensorflow==2.10
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Requirement already satisfied: google-auth-oauthlib<0.5,>=0.4.1 in /usr/local/lib/python3.10/dist-packages (from tensorboard<2.11,>
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Requirement already satisfied: requests<3,>=2.21.0 in /usr/local/lib/python3.10/dist-packages (from tensorboard<2.11,>=2.10->tensor
Requirement already satisfied: tensorboard-data-server<0.7.0,>=0.6.0 in /usr/local/lib/python3.10/dist-packages (from tensorboard<2
Requirement already satisfied: tensorboard-plugin-wit>=1.6.0 in /usr/local/lib/python3.10/dist-packages (from tensorboard<2.11,>=2.
Requirement already satisfied: werkzeug>=1.0.1 in /usr/local/lib/python3.10/dist-packages (from tensorboard<2.11,>=2.10->tensorflow
Requirement already satisfied: cachetools<6.0,>=2.0.0 in /usr/local/lib/python3.10/dist-packages (from google-auth<3,>=1.6.3->tenso
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Requirement already satisfied: idna<4,>=2.5 in /usr/local/lib/python3.10/dist-packages (from requests<3,>=2.21.0->tensorboard<2.11,
Requirement already satisfied: MarkupSafe>=2.1.1 in /usr/local/lib/python3.10/dist-packages (from werkzeug>=1.0.1->tensorboard<2.11
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Requirement already satisfied: numpy>=1.14.5 in /usr/local/lib/python3.10/dist-packages (from h5py==3.7.0) (1.22.4)
```

```
!pip install efficientnet
```

```
Requirement already satisfied: efficientnet in /usr/local/lib/python3.10/dist-packages (1.1.1)
Requirement already satisfied: keras-applications<=1.0.8,>=1.0.7 in /usr/local/lib/python3.10/dist-packages (from efficientnet) (1.
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Requirement already satisfied: h5py in /usr/local/lib/python3.10/dist-packages (from keras-applications<=1.0.8,>=1.0.7->efficientne
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Requirement already satisfied: pillow!=7.1.0,!=7.1.1,!=8.3.0,>=6.1.0 in /usr/local/lib/python3.10/dist-packages (from scikit-image-
Requirement already satisfied: imageio>=2.4.1 in /usr/local/lib/python3.10/dist-packages (from scikit-image->efficientnet) (2.25.1)
Requirement already satisfied: tifffile>=2019.7.26 in /usr/local/lib/python3.10/dist-packages (from scikit-image->efficientnet) (20
Requirement already satisfied: PyWavelets>=1.1.1 in /usr/local/lib/python3.10/dist-packages (from scikit-image->efficientnet) (1.4.
Requirement already satisfied: packaging>=20.0 in /usr/local/lib/python3.10/dist-packages (from scikit-image->efficientnet) (23.1)
```

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

```
Drive already mounted at /content/drive; to attempt to forcibly remount, call drive.mount("/content/drive", force_remount=True).
```

```
#!unzip /content/drive/MyDrive/car_damage_classification/Data.zip -d /content/drive/MyDrive/car_damage_classification
```

```
Archive:  /content/drive/MyDrive/car_damage_classification/Data.zip
   creating: /content/drive/MyDrive/car_damage_classification/Data/
   creating: /content/drive/MyDrive/car_damage_classification/Data/training/
   creating: /content/drive/MyDrive/car_damage_classification/Data/training/damage/
  inflating: /content/drive/MyDrive/car_damage_classification/Data/training/damage/0001.JPEG
  inflating: /content/drive/MyDrive/car_damage_classification/Data/training/damage/0002.JPEG
  inflating: /content/drive/MyDrive/car_damage_classification/Data/training/damage/0003.JPEG
  inflating: /content/drive/MyDrive/car_damage_classification/Data/training/damage/0004.JPEG
  inflating: /content/drive/MyDrive/car_damage_classification/Data/training/damage/0005.JPEG
  inflating: /content/drive/MyDrive/car_damage_classification/Data/training/damage/0006.JPEG
  inflating: /content/drive/MyDrive/car_damage_classification/Data/training/damage/0007.JPEG
```

```
inflating: /content/drive/MyDrive/car_damage_classification/Data/training/damage/0008.JPEG
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inflating: /content/drive/MyDrive/car_damage_classification/Data/training/damage/0052.JPEG
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inflating: /content/drive/MyDrive/car_damage_classification/Data/training/damage/0054.JPEG
```

```
import numpy as np
import pickle
import os
from tqdm import tqdm
import cv2
import pandas as pd
import seaborn as sns
from os import listdir
import tensorflow as tf
from sklearn.preprocessing import LabelBinarizer
from keras.models import Sequential
from sklearn.utils import shuffle
from keras.layers.convolutional import Conv2D
from keras.layers.convolutional import MaxPooling2D
from keras.layers.core import Activation, Flatten, Dropout, Dense
from keras import backend as K
from keras.preprocessing.image import ImageDataGenerator
from keras.optimizers import Adam,SGD
from keras.preprocessing import image
from tensorflow.keras.preprocessing.image import img_to_array
from keras.utils import to_categorical
import imblearn
from imblearn.over_sampling import SMOTE
from sklearn.preprocessing import MultiLabelBinarizer
from sklearn.model_selection import train_test_split
import matplotlib.pyplot as plt
from tensorflow.keras.models import load_model
from keras.models import Model
from tensorflow.keras.layers import Input
from keras.layers import Dense, Dropout, Flatten, Conv2D, MaxPool2D, BatchNormalization, AveragePooling2D, GlobalAveragePooling2D
from keras.callbacks import ModelCheckpoint, ReduceLROnPlateau
from keras import layers
from sklearn.metrics import classification_report,confusion_matrix
import efficientnet.keras as effnet


from tensorflow.keras import backend as K
K.clear_session()
```

```
image_size=128
default_image_size = tuple((128, 128))
labels = os.listdir('/content/drive/MyDrive/car_damage_classification/Data/training')
directory_root = '/content/drive/MyDrive/car_damage_classification/Data'
classes = len(labels)
BATCHZ_SIZE=32


def image_array(dir):
    try:
        img = cv2.imread(dir)
        if img is not None :
            img = cv2.resize(img, default_image_size)
            return img_to_array(img)
        else :
            return np.array([])
    except Exception as e:
        print(f"Error : {e}")
        return None


image_list, label_list = [], []

try:
    print("[INFO] Loading images ...")
    root_dir = listdir(directory_root)
    for directory in root_dir :
        # remove .DS_Store from list
        if directory == ".DS_Store" :
            root_dir.remove(directory)

    for classes_folder in root_dir :
        image_classes_folder_list = listdir(f"/content/drive/MyDrive/car_damage_classification/Data/training")

    for classes_folder in image_classes_folder_list :
            # remove .DS_Store from list
            if classes_folder == ".DS_Store" :
                image_classes_folder_list.remove(classes_folder)

    for i in listdir('/content/drive/MyDrive/car_damage_classification/Data'):
      for  image_classes_folder in image_classes_folder_list:
              print(f"[INFO] Processing { image_classes_folder} ...")
              image_classes_image_list = listdir(f"{directory_root}/{i}/{ image_classes_folder}/")

              for single_image_classes_image in image_classes_image_list :
                  if single_image_classes_image == ".DS_Store" :
                      image_classes_image_list.remove(single_image_classes_image)

              for image in image_classes_image_list[:]:
                  image_directory = f"{directory_root}/{i}/{ image_classes_folder}/{image}"
                  if image_directory.endswith(".jpg") == True or image_directory.endswith(".JPG") == True or image_directory.endswith(".p
                      image_list.append(image_array(image_directory))
                      label_list.append( image_classes_folder)
      print("[INFO] Image loading completed")
except Exception as e:
    print(f"Error : {e}")
```

```
[INFO] Loading images ...
[INFO] Processing damage ...
[INFO] Processing nodamage ...
[INFO] Image loading completed
[INFO] Processing damage ...
[INFO] Processing nodamage ...
[INFO] Image loading completed
```

```
X = image_list
Y = label_list


X = np.array(X)


X, Y = shuffle(X, Y)
print(X.shape)
```

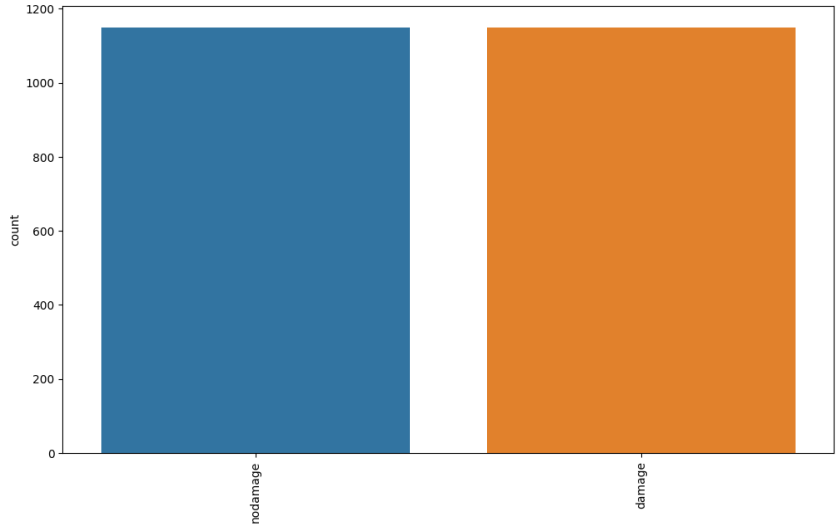
```
(2300, 128, 128, 3)
```

```
#Data Visualization
import matplotlib.image as mpimg
plt.figure(figsize = (20, 40))
image_count = 1
```

```
BASE_URL = '/content/drive/MyDrive/car_damage_classification/Data/training/'
for directory in os.listdir(BASE_URL):
    if directory[0] != '.':
        for i, file in enumerate(os.listdir(BASE_URL + directory)):
            if i == 1:
                break
            else:
                fig = plt.subplot(13, 3, image_count)
                image_count += 1
                image = mpimg.imread(BASE_URL + directory + '/' + file)
                plt.imshow(image)
                plt.title(directory)
```


```
#count plot
plt.figure(figsize = (12, 7))
plt.xticks(rotation=90)
sns.countplot(x=Y)
```

```
<Axes: ylabel='count'>
```




```
class_labels = LabelBinarizer()
Y = class_labels.fit_transform(Y)
pickle.dump(class_labels,open('/content/drive/MyDrive/car_damage_classification/label_transform.pkl', 'wb'))
n_classes = len(class_labels.classes_)
```

```
cls = len(class_labels.classes_)
print(class_labels.classes_)
```

```
['damage' 'nodamage']
```

```
Y = to_categorical(Y)
```

```
X_train, X_test, y_train, y_test = train_test_split(X, Y, test_size=0.1)


X_train, X_val, y_train, y_val = train_test_split(X_train, y_train, test_size=0.1)
```

CNN

```
#CNN
depth=3
model = Sequential()
inputShape = (image_size, image_size, depth)
chanDim = -1
if K.image_data_format() == "channels_first":
    inputShape = (depth, image_size, image_size)
    chanDim = 1
model.add(Conv2D(32, (3, 3), padding="same",input_shape=inputShape))
model.add(Activation("relu"))
model.add(BatchNormalization(axis=chanDim))
model.add(MaxPooling2D(pool_size=(3, 3)))
model.add(Dropout(0.25))
model.add(Conv2D(64, (3, 3), padding="same"))
model.add(Activation("relu"))
model.add(BatchNormalization(axis=chanDim))
model.add(Conv2D(64, (3, 3), padding="same"))
model.add(Activation("relu"))
model.add(BatchNormalization(axis=chanDim))
model.add(MaxPooling2D(pool_size=(2, 2)))
model.add(Dropout(0.25))
model.add(Conv2D(128, (3, 3), padding="same"))
model.add(Activation("relu"))
model.add(BatchNormalization(axis=chanDim))
model.add(Conv2D(128, (3, 3), padding="same"))
model.add(Activation("relu"))
model.add(BatchNormalization(axis=chanDim))
model.add(MaxPooling2D(pool_size=(2, 2)))
model.add(Dropout(0.25))
model.add(Flatten())
model.add(Dense(1024))
model.add(Activation("relu"))
model.add(BatchNormalization())
model.add(Dropout(0.25))
model.add(Dense(cls))
model.add(Activation("softmax"))
model.summary()
```

```
Model: "sequential_1"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d_5 (Conv2D)           (None, 128, 128, 32)      896

 activation_7 (Activation)   (None, 128, 128, 32)      0

 batch_normalization_6 (Batc  (None, 128, 128, 32)     128
 hNormalization)

 max_pooling2d_3 (MaxPooling  (None, 42, 42, 32)       0
 2D)

 dropout_4 (Dropout)         (None, 42, 42, 32)        0

 conv2d_6 (Conv2D)           (None, 42, 42, 64)        18496

 activation_8 (Activation)   (None, 42, 42, 64)        0

 batch_normalization_7 (Batc  (None, 42, 42, 64)       256
 hNormalization)

 conv2d_7 (Conv2D)           (None, 42, 42, 64)        36928

 activation_9 (Activation)   (None, 42, 42, 64)        0

 batch_normalization_8 (Batc  (None, 42, 42, 64)       256
 hNormalization)

 max_pooling2d_4 (MaxPooling  (None, 21, 21, 64)       0
 2D)

 dropout_5 (Dropout)         (None, 21, 21, 64)        0

 conv2d_8 (Conv2D)           (None, 21, 21, 128)       73856

 activation_10 (Activation)  (None, 21, 21, 128)       0
```

```
batch_normalization_9 (Batc  (None, 21, 21, 128)      512
hNormalization)

conv2d_9 (Conv2D)           (None, 21, 21, 128)       147584

activation_11 (Activation)  (None, 21, 21, 128)       0

batch_normalization_10 (Bat  (None, 21, 21, 128)      512
chNormalization)

max_pooling2d_5 (MaxPooling  (None, 10, 10, 128)      0
2D)

dropout_6 (Dropout)         (None, 10, 10, 128)       0

flatten_1 (Flatten)         (None, 12800)             0

dense_2 (Dense)             (None, 1024)              13108224
```

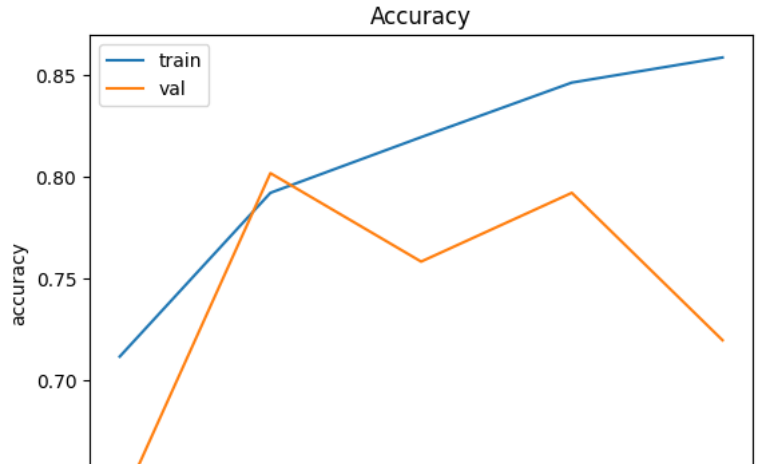
```
model.compile(loss="categorical_crossentropy", optimizer= "adam", metrics=["accuracy"])
```

```
history = model.fit(X_train, y_train,batch_size=BATCHZ_SIZE,validation_data=(X_val, y_val),epochs=5, verbose=1)
```

```
Epoch 1/5
59/59 [==============================] - 12s 41ms/step - loss: 0.8067 - accuracy: 0.7118 - val_loss: 0.6968 - val_accuracy: 0.6377
Epoch 2/5
59/59 [==============================] - 2s 30ms/step - loss: 0.4380 - accuracy: 0.7923 - val_loss: 0.4913 - val_accuracy: 0.8019
Epoch 3/5
59/59 [==============================] - 2s 29ms/step - loss: 0.4198 - accuracy: 0.8196 - val_loss: 0.6908 - val_accuracy: 0.7585
Epoch 4/5
59/59 [==============================] - 2s 30ms/step - loss: 0.3732 - accuracy: 0.8465 - val_loss: 0.4925 - val_accuracy: 0.7923
Epoch 5/5
59/59 [==============================] - 2s 31ms/step - loss: 0.3408 - accuracy: 0.8588 - val_loss: 0.6317 - val_accuracy: 0.7198
```

```
#accuracy and loss plot
plt.plot(history.history['accuracy'])
plt.plot(history.history['val_accuracy'])
plt.title('Accuracy')
plt.ylabel('accuracy')
plt.xlabel('epoch')
plt.legend(['train','val'], loc='upper left')
plt.show()
```

```
#loss plot
plt.plot(history.history['loss'])
plt.plot(history.history['val_loss'])
plt.title('model loss')
plt.ylabel('loss')
plt.xlabel('epoch')
plt.legend(['train','val'], loc='upper left')
plt.show()
```

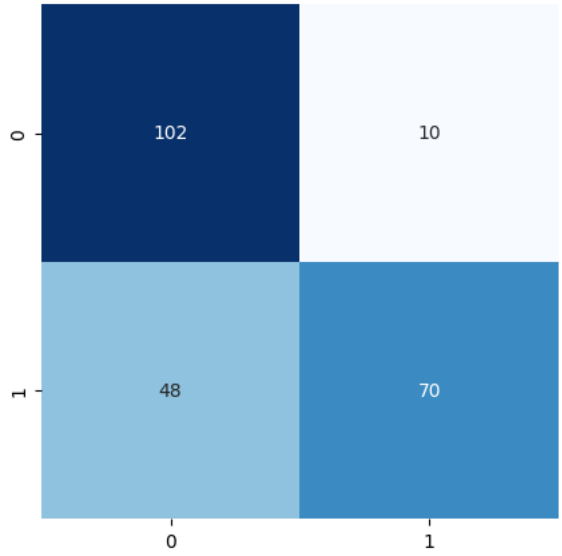



```
pred = model.predict(X_test)
pred = np.argmax(pred,axis=1)
y_test_new = np.argmax(y_test,axis=1)
```

```
8/8 [==============================] - 0s 30ms/step
```



```
cmat = confusion_matrix(y_test_new,pred)
plt.figure(figsize=(5,5))
sns.heatmap(cmat, annot = True, cbar = False, cmap='Blues', fmt="d");
```




```
print(classification_report(y_test_new,pred))
```

```
                  precision    recall  f1-score   support

               0       0.68      0.91      0.78       112
               1       0.88      0.59      0.71       118

        accuracy                           0.75       230
       macro avg       0.78      0.75      0.74       230
    weighted avg       0.78      0.75      0.74       230
```

```
from sklearn.metrics import precision_recall_fscore_support
res = []
for l in range(cls):
    prec,recall,_,_ = precision_recall_fscore_support(y_test_new==l,
                                                      pred==l,
                                                      pos_label=True,average=None)
    res.append([l,recall[0],recall[1]])

pd.DataFrame(res,columns = ['class','sensitivity','specificity'])
```

	class	sensitivity	specificity
0	0	0.593220	0.910714
1	1	0.910714	0.593220

VGG16

```
from keras.applications import vgg16
def build_model(backbone):
    model = Sequential()
    model.add(backbone)
    model.add(layers.GlobalAveragePooling2D())
    model.add(layers.Dropout(0.5))
    model.add(layers.BatchNormalization())
    model.add(layers.Dense(cls, activation='softmax'))


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

    return model


vgg_model = vgg16.VGG16(weights="imagenet",
                        include_top=False,
                        input_shape=(image_size,image_size,3))

base_model = vgg16.VGG16
trainable_layers = 4

base_model = base_model(weights="imagenet", include_top=False, input_shape=(image_size,image_size,3))

for layer in base_model.layers[:-trainable_layers]:
        layer.trainable = False


model = build_model(base_model)
model.summary()
```

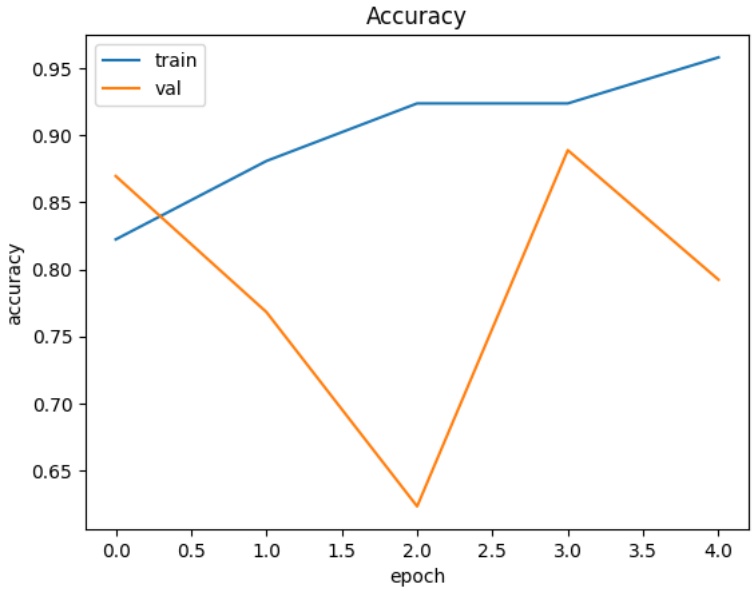
```
Model: "sequential_3"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 vgg16 (Functional)          (None, 4, 4, 512)         14714688

 global_average_pooling2d_1   (None, 512)              0
 (GlobalAveragePooling2D)

 dropout_9 (Dropout)         (None, 512)               0

 batch_normalization_13 (Bat  (None, 512)              2048
 chNormalization)

 dense_5 (Dense)             (None, 2)                 1026

=================================================================
Total params: 14,717,762
Trainable params: 7,081,474
Non-trainable params: 7,636,288
_________________________________________________________________
```

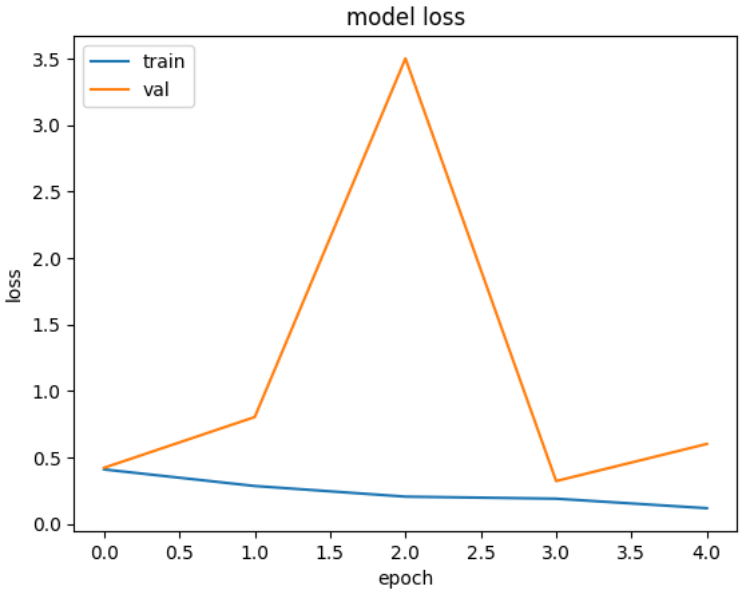
```
model.compile(loss='categorical_crossentropy', optimizer="adam", metrics=['accuracy'])


history = model.fit(X_train, y_train,batch_size=BATCHZ_SIZE,validation_data=(X_val, y_val),epochs=5, verbose=1)
```

```
Epoch 1/5
59/59 [==============================] - 10s 120ms/step - loss: 0.4084 - accuracy: 0.8223 - val_loss: 0.4207 - val_accuracy: 0.8696
Epoch 2/5
59/59 [==============================] - 3s 59ms/step - loss: 0.2838 - accuracy: 0.8808 - val_loss: 0.8029 - val_accuracy: 0.7681
Epoch 3/5
59/59 [==============================] - 3s 59ms/step - loss: 0.2037 - accuracy: 0.9238 - val_loss: 3.5014 - val_accuracy: 0.6232
Epoch 4/5
59/59 [==============================] - 3s 59ms/step - loss: 0.1882 - accuracy: 0.9238 - val_loss: 0.3209 - val_accuracy: 0.8889
Epoch 5/5
59/59 [==============================] - 4s 61ms/step - loss: 0.1166 - accuracy: 0.9581 - val_loss: 0.6004 - val_accuracy: 0.7923
```

```
#accuracy and loss plot
plt.plot(history.history['accuracy'])
plt.plot(history.history['val_accuracy'])
plt.title('Accuracy')
plt.ylabel('accuracy')
plt.xlabel('epoch')
plt.legend(['train','val'], loc='upper left')
```

```
plt.show()


#loss plot
plt.plot(history.history['loss'])
plt.plot(history.history['val_loss'])
plt.title('model loss')
plt.ylabel('loss')
plt.xlabel('epoch')
plt.legend(['train','val'], loc='upper left')
plt.show()
```

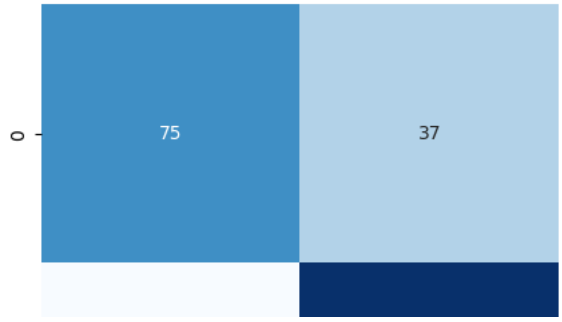





```
pred = model.predict(X_test)
pred = np.argmax(pred,axis=1)
y_test_new = np.argmax(y_test,axis=1)
```

```
     8/8 [==============================] - 1s 153ms/step
```

```
cmat = confusion_matrix(y_test_new,pred)
plt.figure(figsize=(5,5))
sns.heatmap(cmat, annot = True, cbar = False, cmap='Blues', fmt="d");
```




```
print(classification_report(y_test_new,pred))
```

```
                  precision    recall  f1-score   support

               0       1.00      0.67      0.80       112
               1       0.76      1.00      0.86       118

        accuracy                           0.84       230
       macro avg       0.88      0.83      0.83       230
    weighted avg       0.88      0.84      0.83       230
```

```
from sklearn.metrics import precision_recall_fscore_support
res = []
for l in range(cls):
    prec,recall,_,_ = precision_recall_fscore_support(y_test_new==l,
                                                      pred==l,
                                                      pos_label=True,average=None)
    res.append([l,recall[0],recall[1]])

pd.DataFrame(res,columns = ['class','sensitivity','specificity'])
```

	class	sensitivity	specificity
0	0	1.000000	0.669643
1	1	0.669643	1.000000

Resnet50

```
from tensorflow.keras.models import Model
from tensorflow.keras.layers import Dense, Flatten, GlobalAveragePooling2D, BatchNormalization, Dropout
from tensorflow.keras.applications import ResNet50
from tensorflow.keras.callbacks import ModelCheckpoint, EarlyStopping, ReduceLROnPlateau, CSVLogger


resnet = ResNet50(weights= None, include_top=False, input_shape= X_train.shape[1:])


x = resnet.output
x = GlobalAveragePooling2D()(x)
x = Dropout(0.5)(x)
predictions = Dense(cls, activation= 'softmax')(x)
model = Model(inputs = resnet.input, outputs = predictions)


model.summary()
```

```
Model: "model"
__________________________________________________________________________________________________
 Layer (type)                   Output Shape         Param #     Connected to
==================================================================================================
 input_5 (InputLayer)           [(None, 128, 128, 3  0           []
                                )]

 conv1_pad (ZeroPadding2D)      (None, 134, 134, 3)  0           ['input_5[0][0]']

 conv1_conv (Conv2D)            (None, 64, 64, 64)   9472        ['conv1_pad[0][0]']

 conv1_bn (BatchNormalization)  (None, 64, 64, 64)   256         ['conv1_conv[0][0]']

 conv1_relu (Activation)        (None, 64, 64, 64)   0           ['conv1_bn[0][0]']

 pool1_pad (ZeroPadding2D)      (None, 66, 66, 64)   0           ['conv1_relu[0][0]']

 pool1_pool (MaxPooling2D)      (None, 32, 32, 64)   0           ['pool1_pad[0][0]']

 conv2_block1_1_conv (Conv2D)   (None, 32, 32, 64)   4160        ['pool1_pool[0][0]']

 conv2_block1_1_bn (BatchNormal  (None, 32, 32, 64)  256         ['conv2_block1_1_conv[0][0]']
```

```
ization)

conv2_block1_1_relu (Activatio  (None, 32, 32, 64)  0           ['conv2_block1_1_bn[0][0]']
n)

conv2_block1_2_conv (Conv2D)   (None, 32, 32, 64)   36928       ['conv2_block1_1_relu[0][0]']

conv2_block1_2_bn (BatchNormal  (None, 32, 32, 64)  256         ['conv2_block1_2_conv[0][0]']
ization)

conv2_block1_2_relu (Activatio  (None, 32, 32, 64)  0           ['conv2_block1_2_bn[0][0]']
n)

conv2_block1_0_conv (Conv2D)   (None, 32, 32, 256)  16640       ['pool1_pool[0][0]']

conv2_block1_3_conv (Conv2D)   (None, 32, 32, 256)  16640       ['conv2_block1_2_relu[0][0]']

conv2_block1_0_bn (BatchNormal  (None, 32, 32, 256)  1024       ['conv2_block1_0_conv[0][0]']
ization)

conv2_block1_3_bn (BatchNormal  (None, 32, 32, 256)  1024       ['conv2_block1_3_conv[0][0]']
ization)

conv2_block1_add (Add)         (None, 32, 32, 256)  0           ['conv2_block1_0_bn[0][0]',
                                                                 'conv2_block1_3_bn[0][0]']

conv2_block1_out (Activation)  (None, 32, 32, 256)  0           ['conv2_block1_add[0][0]']

conv2_block2_1_conv (Conv2D)   (None, 32, 32, 64)   16448       ['conv2_block1_out[0][0]']

conv2_block2_1_bn (BatchNormal  (None, 32, 32, 64)  256         ['conv2_block2_1_conv[0][0]']
ization)

conv2_block2_1_relu (Activatio  (None, 32, 32, 64)  0           ['conv2_block2_1_bn[0][0]']
n)
```

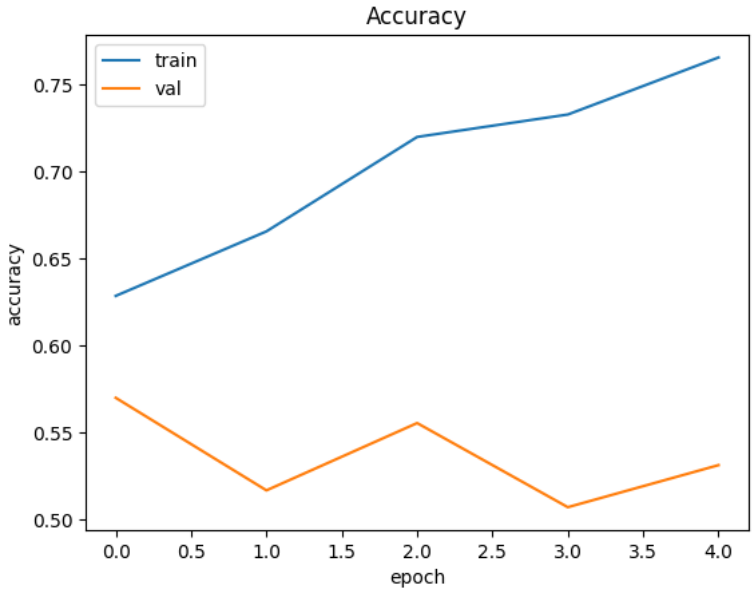
```
model.compile(optimizer='adam', loss='categorical_crossentropy', metrics=['accuracy'])
```

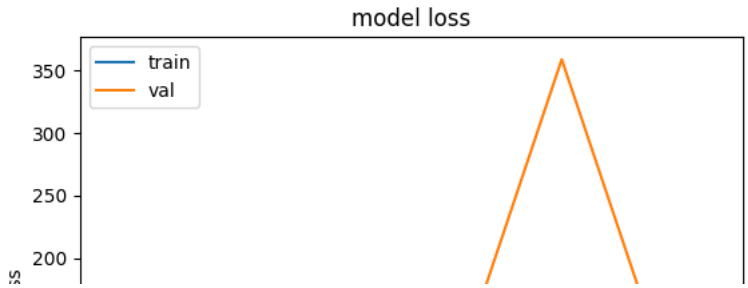
```
history = model.fit(X_train, y_train,batch_size=BATCHZ_SIZE,validation_data=(X_val, y_val),epochs=5, verbose=1)
```

```
Epoch 1/5
59/59 [==============================] - 18s 164ms/step - loss: 1.1320 - accuracy: 0.6286 - val_loss: 10.8030 - val_accuracy: 0.570
Epoch 2/5
59/59 [==============================] - 7s 125ms/step - loss: 0.7408 - accuracy: 0.6656 - val_loss: 0.7248 - val_accuracy: 0.5169
Epoch 3/5
59/59 [==============================] - 7s 127ms/step - loss: 0.6772 - accuracy: 0.7198 - val_loss: 0.7562 - val_accuracy: 0.5556
Epoch 4/5
59/59 [==============================] - 7s 126ms/step - loss: 0.6627 - accuracy: 0.7327 - val_loss: 358.4745 - val_accuracy: 0.507
Epoch 5/5
59/59 [==============================] - 8s 128ms/step - loss: 0.5959 - accuracy: 0.7654 - val_loss: 0.8404 - val_accuracy: 0.5314
```

```
#accuracy and loss plot
plt.plot(history.history['accuracy'])
plt.plot(history.history['val_accuracy'])
plt.title('Accuracy')
plt.ylabel('accuracy')
plt.xlabel('epoch')
plt.legend(['train','val'], loc='upper left')
plt.show()
```

```
#loss plot
plt.plot(history.history['loss'])
plt.plot(history.history['val_loss'])
plt.title('model loss')
plt.ylabel('loss')
plt.xlabel('epoch')
plt.legend(['train','val'], loc='upper left')
plt.show()
```

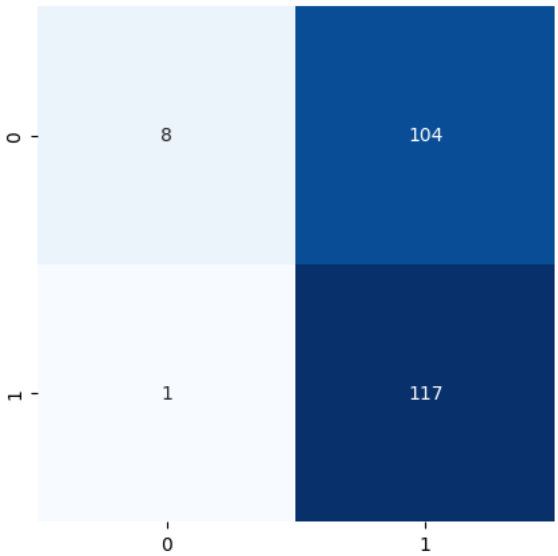





```
pred = model.predict(X_test)
pred = np.argmax(pred,axis=1)
y_test_new = np.argmax(y_test,axis=1)
```

```
8/8 [==============================] - 2s 93ms/step
```

```
cmat = confusion_matrix(y_test_new,pred)
plt.figure(figsize=(5,5))
sns.heatmap(cmat, annot = True, cbar = False, cmap='Blues', fmt="d");
```




```
print(classification_report(y_test_new,pred))
```

```
              precision    recall  f1-score   support

           0       0.89      0.07      0.13       112
           1       0.53      0.99      0.69       118

    accuracy                           0.54       230
   macro avg       0.71      0.53      0.41       230
weighted avg       0.70      0.54      0.42       230
```

```
from sklearn.metrics import precision_recall_fscore_support
res = []
for l in range(cls):
    prec,recall,_,_ = precision_recall_fscore_support(y_test_new==l,
                                                      pred==l,
                                                      pos_label=True,average=None)
    res.append([l,recall[0],recall[1]])

pd.DataFrame(res,columns = ['class','sensitivity','specificity'])
```

	class	sensitivity	specificity
0	0	0.991525	0.071429
1	1	0.071429	0.991525

EfficientNetB2

```
base_model = effnet.EfficientNetB2(weights='imagenet', include_top=False, input_shape=(image_size, image_size, 3))
model = base_model.output
model = GlobalAveragePooling2D()(model)
model = Dense(cls, activation='softmax')(model)
model = Model(inputs = base_model.input, outputs=model)
```

```
Downloading data from https://github.com/Callidior/keras-applications/releases/download/efficientnet/efficientnet-b2_weights_tf_dim
31936256/31936256 [==============================] - 0s 0us/step
```

```
model.compile(loss='categorical_crossentropy', optimizer=Adam(), metrics=['accuracy'])
```

```
model.summary()
```

```
Model: "model_1"
__________________________________________________________________________________________________
 Layer (type)                   Output Shape         Param #     Connected to
==================================================================================================
 input_6 (InputLayer)           [(None, 128, 128, 3  0           []
                                )]

 stem_conv (Conv2D)             (None, 64, 64, 32)   864         ['input_6[0][0]']

 stem_bn (BatchNormalization)   (None, 64, 64, 32)   128         ['stem_conv[0][0]']

 stem_activation (Activation)   (None, 64, 64, 32)   0           ['stem_bn[0][0]']

 block1a_dwconv (DepthwiseConv2  (None, 64, 64, 32)  288         ['stem_activation[0][0]']
 D)

 block1a_bn (BatchNormalization  (None, 64, 64, 32)  128         ['block1a_dwconv[0][0]']
 )

 block1a_activation (Activation  (None, 64, 64, 32)  0           ['block1a_bn[0][0]']
 )

 block1a_se_squeeze (GlobalAver  (None, 32)          0           ['block1a_activation[0][0]']
 agePooling2D)

 block1a_se_reshape (Reshape)   (None, 1, 1, 32)     0           ['block1a_se_squeeze[0][0]']

 block1a_se_reduce (Conv2D)     (None, 1, 1, 8)      264         ['block1a_se_reshape[0][0]']

 block1a_se_expand (Conv2D)     (None, 1, 1, 32)     288         ['block1a_se_reduce[0][0]']

 block1a_se_excite (Multiply)   (None, 64, 64, 32)   0           ['block1a_activation[0][0]',
                                                                  'block1a_se_expand[0][0]']

 block1a_project_conv (Conv2D)  (None, 64, 64, 16)   512         ['block1a_se_excite[0][0]']

 block1a_project_bn (BatchNorma  (None, 64, 64, 16)  64          ['block1a_project_conv[0][0]']
 lization)

 block1b_dwconv (DepthwiseConv2  (None, 64, 64, 16)  144         ['block1a_project_bn[0][0]']
 D)

 block1b_bn (BatchNormalization  (None, 64, 64, 16)  64          ['block1b_dwconv[0][0]']
 )

 block1b_activation (Activation  (None, 64, 64, 16)  0           ['block1b_bn[0][0]']
 )

 block1b_se_squeeze (GlobalAver  (None, 16)          0           ['block1b_activation[0][0]']
 agePooling2D)

 block1b_se_reshape (Reshape)   (None, 1, 1, 16)     0           ['block1b_se_squeeze[0][0]']
```

```
block1b_se_reduce (Conv2D)     (None, 1, 1, 4)      68          ['block1b_se_reshape[0][0]']

block1b_se_expand (Conv2D)     (None, 1, 1, 16)     80          ['block1b_se_reduce[0][0]']

block1b_se_excite (Multiply)   (None, 64, 64, 16)   0           ['block1b_activation[0][0]',
```

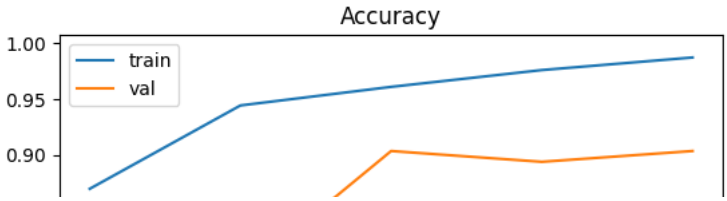
```
history = model.fit(X_train, y_train,batch_size=BATCHZ_SIZE,validation_data=(X_val, y_val),epochs=5, verbose=1)
```

```
Epoch 1/5
59/59 [==============================] - 31s 229ms/step - loss: 0.3415 - accuracy: 0.8696 - val_loss: 1.2843 - val_accuracy: 0.5845
Epoch 2/5
59/59 [==============================] - 10s 167ms/step - loss: 0.1674 - accuracy: 0.9442 - val_loss: 0.7193 - val_accuracy: 0.7923
Epoch 3/5
59/59 [==============================] - 9s 154ms/step - loss: 0.1057 - accuracy: 0.9608 - val_loss: 0.4156 - val_accuracy: 0.9034
Epoch 4/5
59/59 [==============================] - 9s 160ms/step - loss: 0.0855 - accuracy: 0.9758 - val_loss: 0.4839 - val_accuracy: 0.8937
Epoch 5/5
59/59 [==============================] - 11s 180ms/step - loss: 0.0432 - accuracy: 0.9871 - val_loss: 0.4087 - val_accuracy: 0.9034
```

```
#model.save('/content/drive/MyDrive/car_damage_classification/Models/EfficientnetB2.h5')
```

```
#accuracy and loss plot
plt.plot(history.history['accuracy'])
plt.plot(history.history['val_accuracy'])
plt.title('Accuracy')
plt.ylabel('accuracy')
plt.xlabel('epoch')
plt.legend(['train','val'], loc='upper left')
plt.show()
```

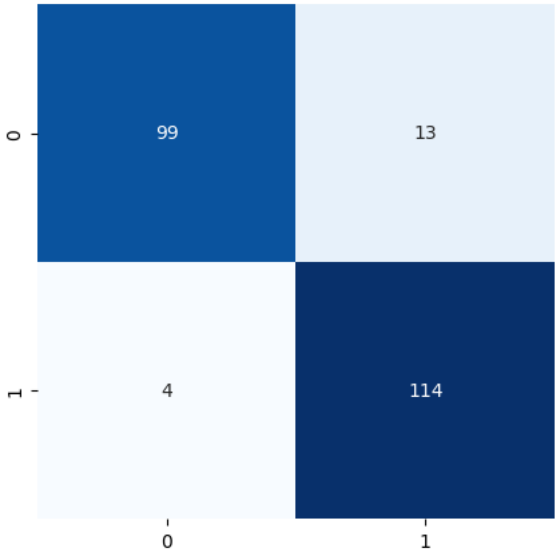
```
#loss plot
plt.plot(history.history['loss'])
plt.plot(history.history['val_loss'])
plt.title('model loss')
plt.ylabel('loss')
plt.xlabel('epoch')
plt.legend(['train','val'], loc='upper left')
plt.show()
```




```
pred = model.predict(X_test)
pred = np.argmax(pred,axis=1)
y_test_new = np.argmax(y_test,axis=1)
```

```
8/8 [==============================] - 3s 107ms/step
```

```
cmat = confusion_matrix(y_test_new,pred)
plt.figure(figsize=(5,5))
sns.heatmap(cmat, annot = True, cbar = False, cmap='Blues', fmt="d");
```




```
print(classification_report(y_test_new,pred))
```

```
                  precision    recall  f1-score   support

               0       0.96      0.88      0.92       112
               1       0.90      0.97      0.93       118

        accuracy                           0.93       230
       macro avg       0.93      0.93      0.93       230
    weighted avg       0.93      0.93      0.93       230
```

```
from sklearn.metrics import precision_recall_fscore_support
res = []
for l in range(cls):
    prec,recall,_,_ = precision_recall_fscore_support(y_test_new==l,
                                                      pred==l,
                                                      pos_label=True,average=None)
    res.append([l,recall[0],recall[1]])

pd.DataFrame(res,columns = ['class','sensitivity','specificity'])
```

	class	sensitivity	specificity
0	0	0.966102	0.883929
1	1	0.883929	0.966102

Testing

```
class_labels = pd.read_pickle(r'/content/drive/MyDrive/car_damage_classification/label_transform.pkl')
label = class_labels.classes_.tolist()
label
```

```
['damage', 'nodamage']
```

```
image = cv2.imread('/content/drive/MyDrive/car_damage_classification/Data/validation/damage/0001.JPEG')
image = img_to_array(image)
image = cv2.resize(image, (image_size, image_size))
image = np.array([image])
```

```
image.shape
```

```
(1, 128, 128, 3)
```

```
model =load_model('/content/drive/MyDrive/car_damage_classification/Models/EfficientnetB2.h5')
prediction=model.predict(image)
print(prediction)
print(max(prediction[0]))
```

```
1/1 [==============================] - 3s 3s/step
[[9.9910200e-01 8.9798676e-04]]
0.999102
```

```
pred_= prediction[0]
pred=[]
for ele in pred_:
  pred.append(ele)
```

```
maxi_ele = max(pred)
idx = pred.index(maxi_ele)
final_class=label
class_name= final_class[idx]
print("Predicted Class Is : " + str(class_name))
```

```
Predicted Class Is : damage
```