simple_CNN_GRAD_CAM-512x1

May 20, 2024

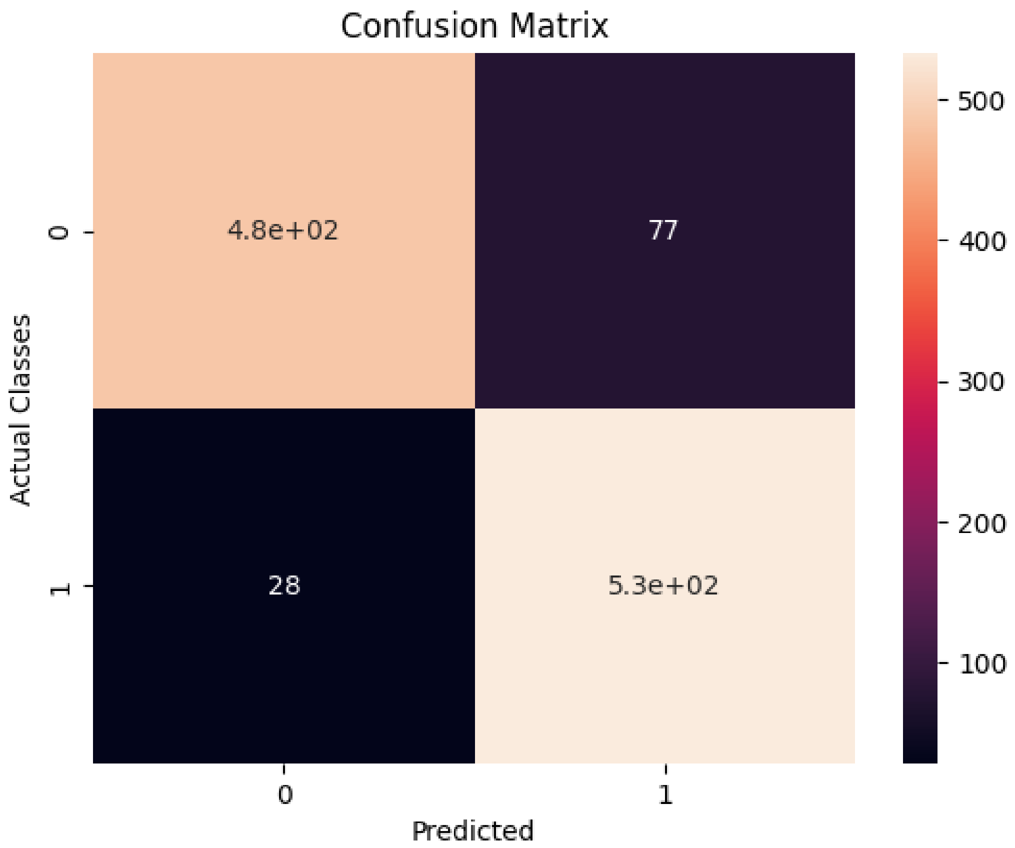
[1]:

```
import os
import pandas as pd
import numpy as np
import seaborn as sns

import tensorflow as tf
from tensorflow.keras import layers, models
from tensorflow.keras.callbacks import ModelCheckpoint
from tensorflow.keras.preprocessing.image import ImageDataGenerator
from tensorflow.keras.preprocessing.image import img_to_array, load_img

from sklearn.metrics import confusion_matrix, classification_report
from sklearn.model_selection import train_test_split

import matplotlib.pyplot as plt
import matplotlib.cm as cm

import cv2

# Update image size to 128x128
w, h = 512, 512
batch_size = 2

train_data_gen = ImageDataGenerator(rescale = 1.0/255)
test_data_gen = ImageDataGenerator(rescale = 1.0/255)

train_Dataset = train_data_gen.flow_from_directory(
    "../images/car/preprocessed_512x/train",
    target_size = (w, h),
    batch_size = batch_size,
    class_mode = 'binary',
    shuffle = True
)

test_Dataset = test_data_gen.flow_from_directory(
    "../images/car/preprocessed_512x/test",
    target_size = (w, h),
    batch_size = batch_size,
    class_mode = 'binary',
    shuffle = False
)

# Update model architecture
model = models.Sequential()
model.add(layers.Conv2D(16, (3, 3), activation='relu', input_shape=(w, h, 3), name='conv2d_1'))
model.add(layers.MaxPooling2D((2, 2), name='max_pooling2d_1'))
model.add(layers.Conv2D(32, (3, 3), activation='relu', name='conv2d_2'))
model.add(layers.MaxPooling2D((2, 2), name='max_pooling2d_2'))
model.add(layers.Conv2D(64, (3, 3), activation='relu', name='conv2d_3'))
model.add(layers.MaxPooling2D((2, 2), name='max_pooling2d_3'))
model.add(layers.Flatten(name='flatten'))
model.add(layers.Dense(128, activation='relu', name='dense_1'))
model.add(layers.Dropout(0.5, name='dropout_1'))
model.add(layers.Dense(1, activation='sigmoid', name='output'))

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

weight_path = './weights/'
model_checkpoint = ModelCheckpoint(
    filepath = weight_path,
    save_best_only = True,
    save_weights_only = True,
    mode = 'max',
    monitor = 'val_accuracy'
)
history = model.fit(train_Dataset,
                    epochs=1,
                    validation_data=test_Dataset,
                    callbacks=[model_checkpoint]
                   )

# Load best weights and make predictions
model.load_weights(weight_path)
predictions = model.predict(test_Dataset)
binary_predictions = (predictions > 0.5).astype(int)

# Generate confusion matrix and classification report
true_labels = test_Dataset.classes
sns.heatmap(confusion_matrix(true_labels, binary_predictions), annot=True)
print(classification_report(true_labels, binary_predictions))
```

```python
plt.title('Confusion Matrix')
plt.xlabel('Predicted')
plt.ylabel('Actual Classes')
plt.show()
```

```
Found 4486 images belonging to 2 classes.
Found 1122 images belonging to 2 classes.
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #   
=================================================================
 conv2d_1 (Conv2D)           (None, 510, 510, 16)      448       
                                                                 
 max_pooling2d_1 (MaxPoolin  (None, 255, 255, 16)      0         
 g2D)                                                            
                                                                 
 conv2d_2 (Conv2D)           (None, 253, 253, 32)      4640      
                                                                 
 max_pooling2d_2 (MaxPoolin  (None, 126, 126, 32)      0         
 g2D)                                                            
                                                                 
 conv2d_3 (Conv2D)           (None, 124, 124, 64)      18496     
                                                                 
 max_pooling2d_3 (MaxPoolin  (None, 62, 62, 64)        0         
 g2D)                                                            
                                                                 
 flatten (Flatten)           (None, 246016)            0         
                                                                 
 dense_1 (Dense)             (None, 128)               31490176  
                                                                 
 dropout_1 (Dropout)         (None, 128)               0         
                                                                 
 output (Dense)              (None, 1)                 129       
                                                                 
=================================================================
Total params: 31513889 (120.22 MB)
Trainable params: 31513889 (120.22 MB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
2243/2243 [==============================] - 794s 354ms/step - loss: 0.3657 -
accuracy: 0.8694 - val_loss: 0.2273 - val_accuracy: 0.9064
561/561 [==============================] - 17s 30ms/step
              precision    recall  f1-score   support

           0       0.95      0.86      0.90       561
           1       0.87      0.95      0.91       561

    accuracy                           0.91      1122
```

```
   macro avg       0.91      0.91      0.91      1122
weighted avg       0.91      0.91      0.91      1122
```



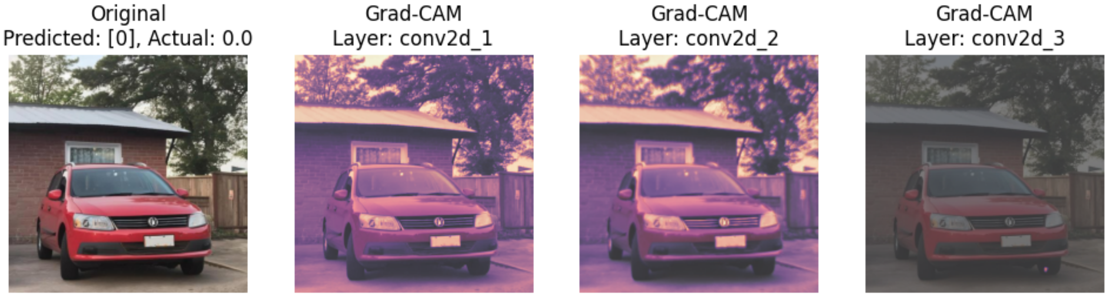
[2]:
```
train_Dataset.class_indices
```

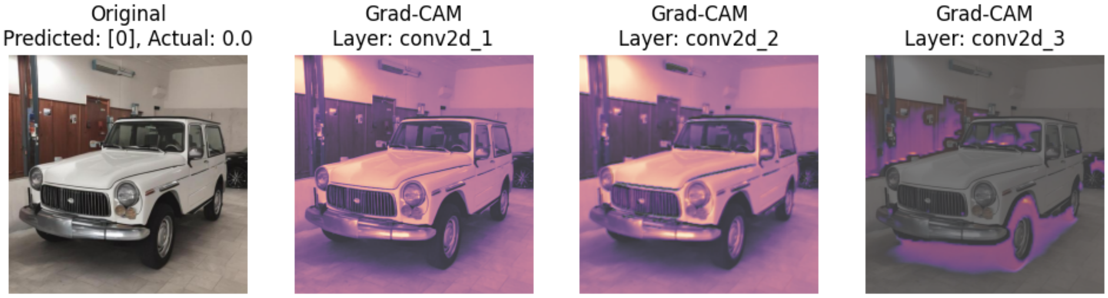
[2]:
```
{'fake': 0, 'real': 1}
```

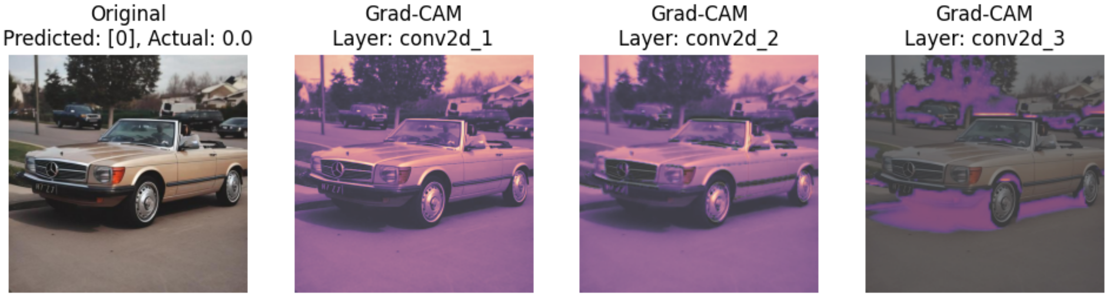
[3]:
```
def make_gradcam_heatmap(img_array, model, last_conv_layer_name,␣
 ↪pred_index=None):
    grad_model = tf.keras.models.Model(
        [model.inputs], [model.get_layer(last_conv_layer_name).output, model.
 ↪output]
    )

    with tf.GradientTape() as tape:
        last_conv_layer_output, preds = grad_model(img_array)
        if pred_index is None:
            pred_index = tf.argmax(preds[0])
        class_channel = preds[:, pred_index]
    grads = tape.gradient(class_channel, last_conv_layer_output)

    pooled_grads = tf.reduce_mean(grads, axis=(0, 1, 2))
    last_conv_layer_output = last_conv_layer_output[0]
    heatmap = last_conv_layer_output @ pooled_grads[..., tf.newaxis]
    heatmap = tf.squeeze(heatmap)

    # Normalize the heatmap
    heatmap = tf.maximum(heatmap, 0) / tf.math.reduce_max(heatmap)

    # Add a channel dimension and resize
    heatmap = tf.expand_dims(heatmap, -1)  # Add a channel dimension
    heatmap = tf.image.resize(heatmap, (w, h))  # Resize heatmap to match the␣
  ↪input image size
    heatmap = tf.squeeze(heatmap)  # Remove the last dimension to make it 2D␣
  ↪again

    return heatmap.numpy(), preds.numpy()
```

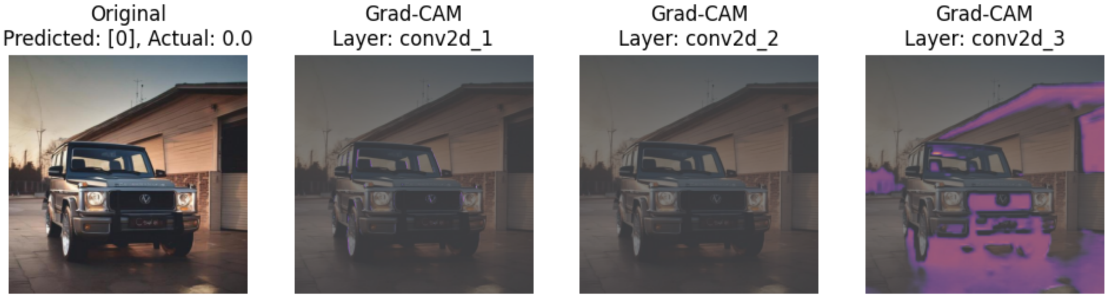
[9]:

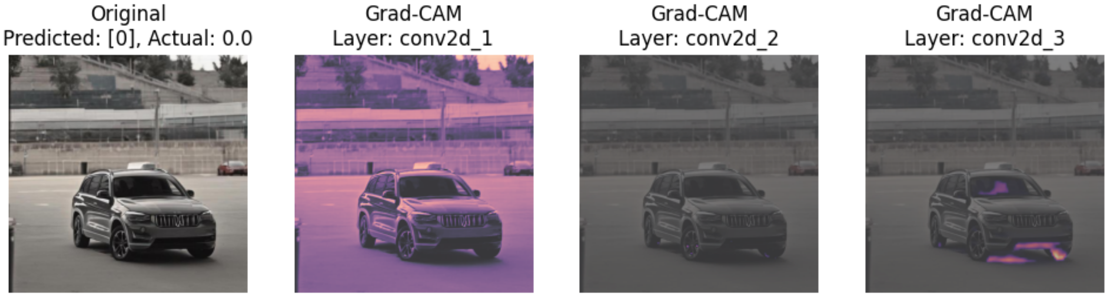
```
counter = 0

for images, labels in test_Dataset:

    for i in range(len(images)):
        if binary_predictions[i] == 0 and labels[i] == 0:
            counter = counter + 1
            image_processed = np.expand_dims(images[i], axis=0)

            plt.figure(figsize=(12, 6))  # Größere Figure, um alle Heatmaps␣
  ↪sichtbar zu machen

            # Ursprüngliches Bild anzeigen
            plt.subplot(1, 4, 1)
            plt.imshow((images[i] * 255).astype("uint8"))
            plt.title(f'Original\nPredicted: {binary_predictions[i]}, Actual:␣
  ↪{labels[i]}')
            plt.axis('off')

            # Heatmaps für jede Layer generieren und anzeigen
            layer_names = ['conv2d_1', 'conv2d_2', 'conv2d_3']
            for j, layer_name in enumerate(layer_names, start=2):  # Startet␣
  ↪bei 2, da das Originalbild auf 1 ist
                heatmap, _ = make_gradcam_heatmap(image_processed, model,␣
  ↪layer_name)

                plt.subplot(1, 4, j)
                plt.imshow((images[i] * 255).astype("uint8"), alpha=0.6)
                plt.imshow(heatmap, cmap='magma', alpha=0.5)  # Ensure heatmap is 2D
                plt.title(f'Grad-CAM\nLayer: {layer_name}')
                plt.axis('off')

            plt.show()

        if i >= 10:
            break
    if counter >= 10:
        break
```

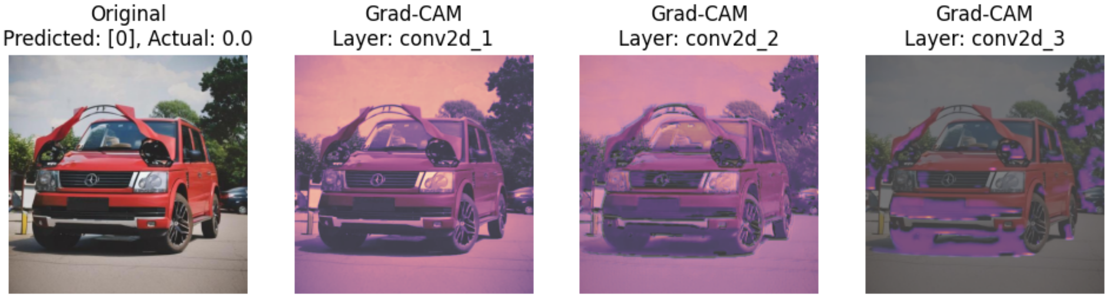


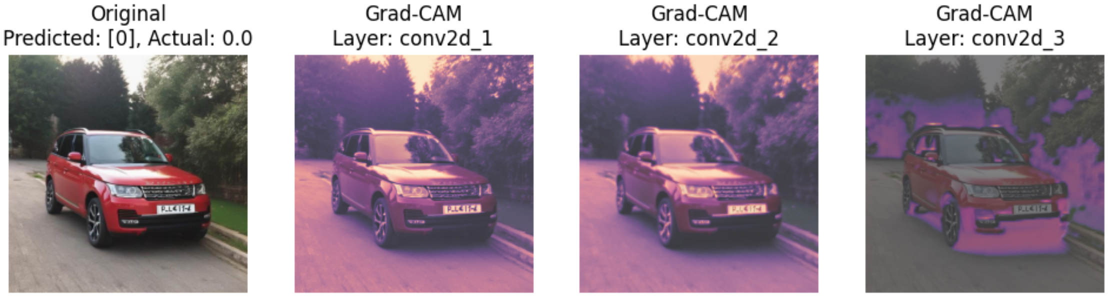


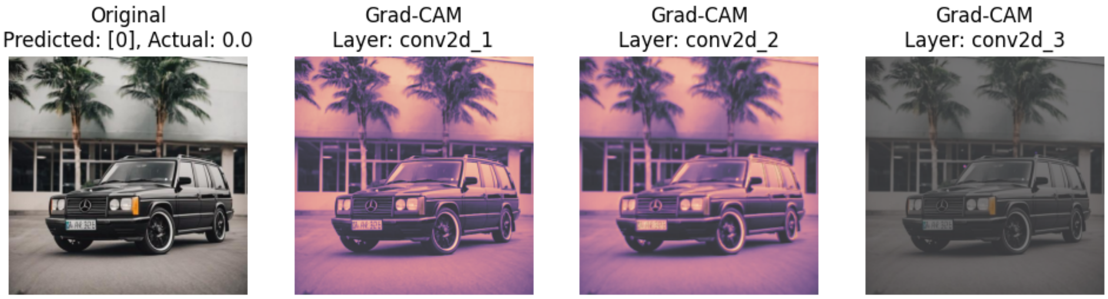


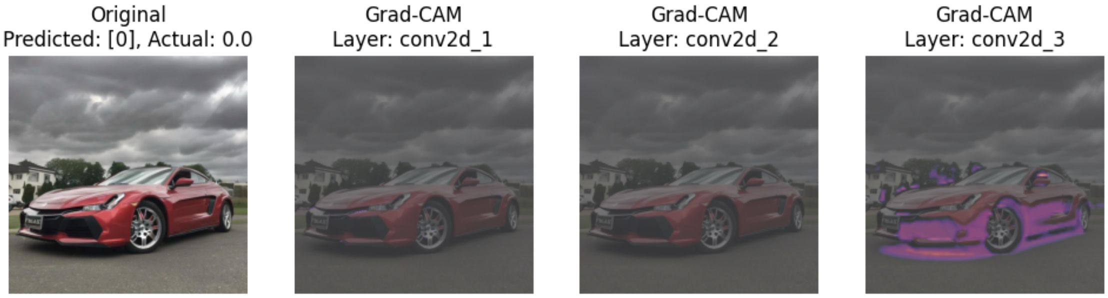

Original
Predicted: [0], Actual: 0.0
Grad-CAM
Layer: conv2d_1
Grad-CAM
Layer: conv2d_2
Grad-CAM
Layer: conv2d_3

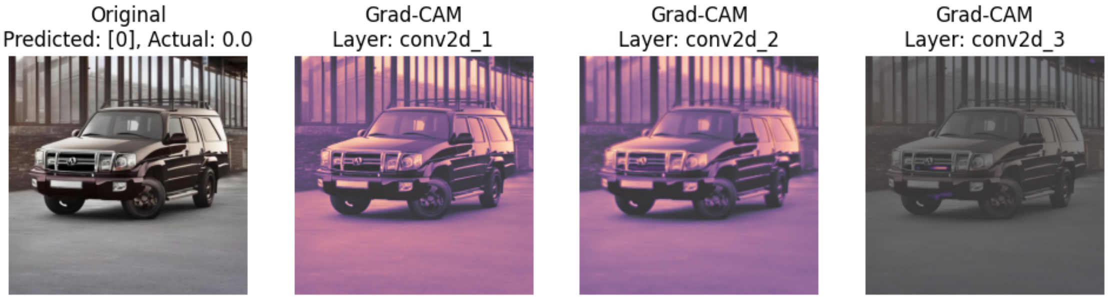

Original
Predicted: [0], Actual: 0.0
Grad-CAM
Layer: conv2d_1
Grad-CAM
Layer: conv2d_2
Grad-CAM
Layer: conv2d_3


Original
Predicted: [0], Actual: 0.0
Grad-CAM
Layer: conv2d_1
Grad-CAM
Layer: conv2d_2
Grad-CAM
Layer: conv2d_3


Original
Predicted: [0], Actual: 0.0
Grad-CAM
Layer: conv2d_1
Grad-CAM
Layer: conv2d_2
Grad-CAM
Layer: conv2d_3


Original
Predicted: [0], Actual: 0.0
Grad-CAM
Layer: conv2d_1
Grad-CAM
Layer: conv2d_2
Grad-CAM
Layer: conv2d_3


Original
Predicted: [0], Actual: 0.0
Grad-CAM
Layer: conv2d_1
Grad-CAM
Layer: conv2d_2
Grad-CAM
Layer: conv2d_3


Original
Predicted: [0], Actual: 0.0
Grad-CAM
Layer: conv2d_1
Grad-CAM
Layer: conv2d_2
Grad-CAM
Layer: conv2d_3