Classify fish species using transfer learning

Having around 9.000 pictures of 9 different seafood types, the goal is to create a model to classify them.

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1. Load and transform the dataset

In [1]:
```
import numpy as np
import pandas as pd
from pathlib import Path
import os.path
import matplotlib.pyplot as plt
from IPython.display import Image, display
import matplotlib.cm as cm
from sklearn.model_selection import train_test_split
import tensorflow as tf
```

In [2]:
```
image_dir = Path('../input/a-large-scale-fish-dataset/Fish_Dataset/Fish_Dataset')

# Get filepaths and labels
filepaths = list(image_dir.glob(r'**/*.png'))
labels = list(map(lambda x: os.path.split(os.path.split(x)[0])[1], filepaths))

filepaths = pd.Series(filepaths, name='Filepath').astype(str)
labels = pd.Series(labels, name='Label')

# Concatenate filepaths and labels
image_df = pd.concat([filepaths, labels], axis=1)

# Drop GT images
image_df = image_df[image_df['Label'].apply(lambda x: x[-2:] != 'GT')]
```

In [3]:
```
# Activate this code to use only 100 pictures for each label
# lst = []
# for l in image_df['Label'].unique():
#     lst.append(image_df[image_df['Label'] == l] .sample(100, random_state = 0))
```

```
# # Concatenate the DataFrames
# image_df = pd.concat(lst)
```

In [4]:
```
# Shuffle the DataFrame and reset index
image_df = image_df.sample(frac=1).reset_index(drop = True)

# Show the result
image_df.head(3)
```

Out[4]:

	Filepath	Label
0	../input/a-large-scale-fish-dataset/Fish_Datas...	Black Sea Sprat
1	../input/a-large-scale-fish-dataset/Fish_Datas...	Shrimp
2	../input/a-large-scale-fish-dataset/Fish_Datas...	Black Sea Sprat

2. Display 15 pictures of the dataset

In [5]:
```
# Display 15 picture of the dataset with their labels
fig, axes = plt.subplots(nrows=3, ncols=5, figsize=(15, 7),
                         subplot_kw={'xticks': [], 'yticks': []})

for i, ax in enumerate(axes.flat):
    ax.imshow(plt.imread(image_df.Filepath[i]))
    ax.set_title(image_df.Label[i])
plt.tight_layout()
plt.show()
```

3. Load the Images with a generator

In [6]:
```
# Separate in train and test data
train_df, test_df = train_test_split(image_df, train_size=0.9, shuffle=True, random_state=1)
```

In [7]:
```
train_generator = tf.keras.preprocessing.image.ImageDataGenerator(
    preprocessing_function=tf.keras.applications.mobilenet_v2.preprocess_input,
    validation_split=0.2
)

test_generator = tf.keras.preprocessing.image.ImageDataGenerator(
    preprocessing_function=tf.keras.applications.mobilenet_v2.preprocess_input
)
```

In [8]:
```
train_images = train_generator.flow_from_dataframe(
    dataframe=train_df,
    x_col='Filepath',
    y_col='Label',
    target_size=(224, 224),
    color_mode='rgb',
    class_mode='categorical',
    batch_size=32,
    shuffle=True,
    seed=42,
    subset='training'
)
```

```
val_images = train_generator.flow_from_dataframe(
    dataframe=train_df,
    x_col='Filepath',
    y_col='Label',
    target_size=(224, 224),
    color_mode='rgb',
    class_mode='categorical',
    batch_size=32,
    shuffle=True,
    seed=42,
    subset='validation'
)

test_images = test_generator.flow_from_dataframe(
    dataframe=test_df,
    x_col='Filepath',
    y_col='Label',
    target_size=(224, 224),
    color_mode='rgb',
    class_mode='categorical',
    batch_size=32,
    shuffle=False
)
```

```
Found 6480 validated image filenames belonging to 9 classes.
Found 1620 validated image filenames belonging to 9 classes.
Found 900 validated image filenames belonging to 9 classes.
```

In [9]:
```
# Load the pretrained model
pretrained_model = tf.keras.applications.MobileNetV2(
    input_shape=(224, 224, 3),
    include_top=False,
    weights='imagenet',
    pooling='avg'
)

pretrained_model.trainable = False
```

```
Downloading data from https://storage.googleapis.com/tensorflow/keras-applications/mobilenet_v2/mobilenet_v2_weights_tf_dim_ordering_tf_kernels_1.0_224_no_top.h5
9412608/9406464 [==============================] - 0s 0us/step
```

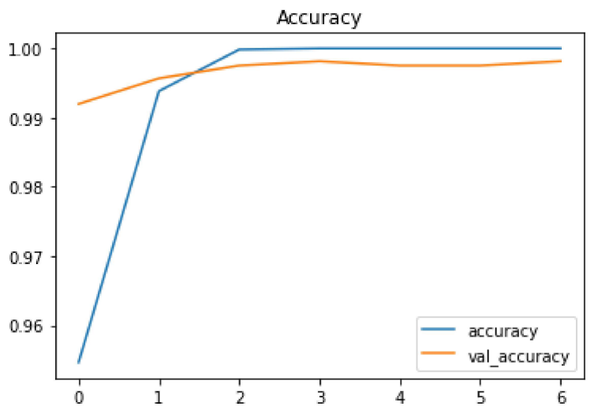
4. Train the model

In [10]:
```
inputs = pretrained_model.input

x = tf.keras.layers.Dense(128, activation='relu')(pretrained_model.output)
x = tf.keras.layers.Dense(128, activation='relu')(x)

outputs = tf.keras.layers.Dense(9, activation='softmax')(x)

model = tf.keras.Model(inputs=inputs, outputs=outputs)

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

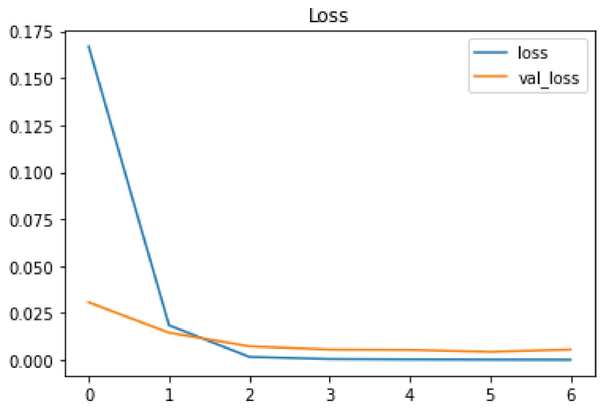
```
history = model.fit(
    train_images,
    validation_data=val_images,
    epochs=50,
    callbacks=[
        tf.keras.callbacks.EarlyStopping(
            monitor='val_loss',
            patience=1,
            restore_best_weights=True
        )
    ]
)
```

```
Epoch 1/50
203/203 [==============================] - 184s 885ms/step - loss: 0.4921 - accuracy: 0.8606 - val_loss: 0.0307 - val_accuracy: 0.9920
Epoch 2/50
203/203 [==============================] - 92s 454ms/step - loss: 0.0175 - accuracy: 0.9945 - val_loss: 0.0146 - val_accuracy: 0.9957
Epoch 3/50
203/203 [==============================] - 92s 453ms/step - loss: 0.0024 - accuracy: 0.9998 - val_loss: 0.0074 - val_accuracy: 0.9975
Epoch 4/50
203/203 [==============================] - 91s 450ms/step - loss: 6.0172e-04 - accuracy: 1.0000 - val_loss: 0.0056 - val_accuracy: 0.9981
Epoch 5/50
203/203 [==============================] - 91s 451ms/step - loss: 4.1682e-04 - accuracy: 1.0000 - val_loss: 0.0054 - val_accuracy: 0.9975
Epoch 6/50
203/203 [==============================] - 94s 463ms/step - loss: 2.5470e-04 - accuracy: 1.0000 - val_loss: 0.0044 - val_accuracy: 0.9975
Epoch 7/50
203/203 [==============================] - 93s 461ms/step - loss: 1.6740e-04 - accuracy: 1.0000 - val_loss: 0.0056 - val_accuracy: 0.9981
```

In [11]:
```
pd.DataFrame(history.history)[['accuracy','val_accuracy']].plot()
plt.title("Accuracy")
plt.show()
```



In [12]:
```
pd.DataFrame(history.history)[['loss','val_loss']].plot()
plt.title("Loss")
plt.show()
```



5. Visualize the result

In [13]:
```
results = model.evaluate(test_images, verbose=0)

print("    Test Loss: {:.5f}".format(results[0]))
print("Test Accuracy: {:.2f}%".format(results[1] * 100))
```

```
    Test Loss: 0.00235
Test Accuracy: 100.00%
```

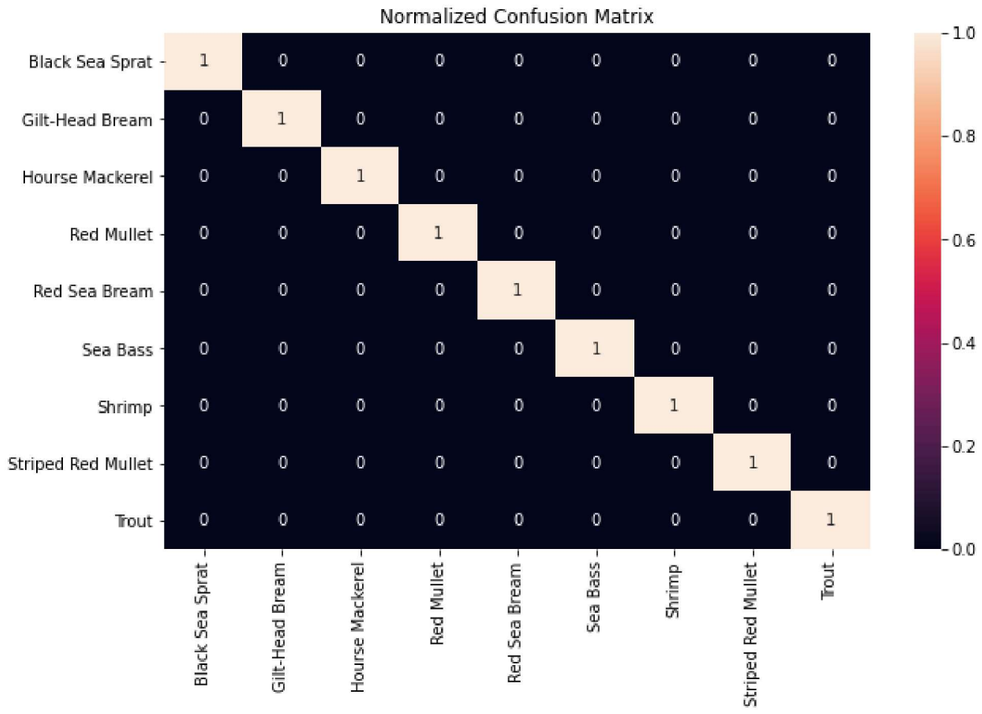
In [14]:
```
# Predict the label of the test_images
pred = model.predict(test_images)
pred = np.argmax(pred,axis=1)

# Map the label
labels = (train_images.class_indices)
labels = dict((v,k) for k,v in labels.items())
pred = [labels[k] for k in pred]

# Display the result
print(f'The first 5 predictions: {pred[:5]}')
```

```
The first 5 predictions: ['Red Sea Bream', 'Shrimp', 'Red Sea Bream', 'Striped Red Mullet', 'Black Sea Sprat']
```

In [15]:
```
from sklearn.metrics import classification_report
y_test = list(test_df.Label)
print(classification_report(y_test, pred))
```

	precision	recall	f1-score	support
Black Sea Sprat	1.00	1.00	1.00	99
Gilt-Head Bream	1.00	1.00	1.00	92
Hourse Mackerel	1.00	1.00	1.00	101
Red Mullet	1.00	1.00	1.00	92
Red Sea Bream	1.00	1.00	1.00	104
Sea Bass	1.00	1.00	1.00	116
Shrimp	1.00	1.00	1.00	98
Striped Red Mullet	1.00	1.00	1.00	103
Trout	1.00	1.00	1.00	95
accuracy			1.00	900
macro avg	1.00	1.00	1.00	900
weighted avg	1.00	1.00	1.00	900

In [16]:
```
from sklearn.metrics import confusion_matrix
import seaborn as sns

cf_matrix = confusion_matrix(y_test, pred, normalize='true')
plt.figure(figsize = (10,6))
sns.heatmap(cf_matrix, annot=True, xticklabels = sorted(set(y_test)), yticklabels = sorted(set(y_test)))
plt.title('Normalized Confusion Matrix')
plt.show()
```



Examples of prediction

In [17]:
```
# Display 15 picture of the dataset with their labels
fig, axes = plt.subplots(nrows=3, ncols=5, figsize=(15, 7),
```

```
                        subplot_kw={'xticks': [], 'yticks': []})

for i, ax in enumerate(axes.flat):
    ax.imshow(plt.imread(test_df.Filepath.iloc[i]))
    ax.set_title(f"True: {test_df.Label.iloc[i]}\nPredicted: {pred[i]}")
plt.tight_layout()
plt.show()
```

6. Class activation heatmap for image classification

In [ ]:
```
## Grad-CAM class activation visualization
*Code adapted from keras.io*
```

In [18]:
```
def get_img_array(img_path, size):
    img = tf.keras.preprocessing.image.load_img(img_path, target_size=size)
    array = tf.keras.preprocessing.image.img_to_array(img)
    # We add a dimension to transform our array into a "batch"
    # of size "size"
    array = np.expand_dims(array, axis=0)
    return array

def make_gradcam_heatmap(img_array, model, last_conv_layer_name, pred_index=None):
    # First, we create a model that maps the input image to the activations
    # of the last conv layer as well as the output predictions
    grad_model = tf.keras.models.Model(
        [model.inputs], [model.get_layer(last_conv_layer_name).output, model.output]
    )
```

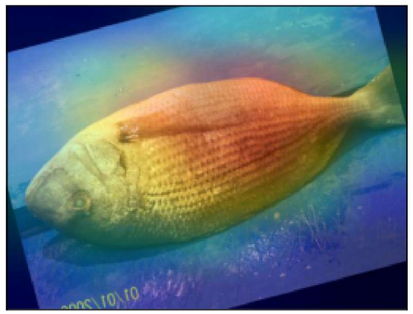
```
    # Then, we compute the gradient of the top predicted class for our input image
    # with respect to the activations of the last conv layer
    with tf.GradientTape() as tape:
        last_conv_layer_output, preds = grad_model(img_array)
        if pred_index is None:
            pred_index = tf.argmax(preds[0])
        class_channel = preds[:, pred_index]

    # This is the gradient of the output neuron (top predicted or chosen)
    # with regard to the output feature map of the last conv layer
    grads = tape.gradient(class_channel, last_conv_layer_output)

    # This is a vector where each entry is the mean intensity of the gradient
    # over a specific feature map channel
    pooled_grads = tf.reduce_mean(grads, axis=(0, 1, 2))

    # We multiply each channel in the feature map array
    # by "how important this channel is" with regard to the top predicted class
    # then sum all the channels to obtain the heatmap class activation
    last_conv_layer_output = last_conv_layer_output[0]
    heatmap = last_conv_layer_output @ pooled_grads[..., tf.newaxis]
    heatmap = tf.squeeze(heatmap)

    # For visualization purpose, we will also normalize the heatmap between 0 & 1
    heatmap = tf.maximum(heatmap, 0) / tf.math.reduce_max(heatmap)
    return heatmap.numpy()

def save_and_display_gradcam(img_path, heatmap, cam_path="cam.jpg", alpha=0.4):
    # Load the original image
    img = tf.keras.preprocessing.image.load_img(img_path)
    img = tf.keras.preprocessing.image.img_to_array(img)

    # Rescale heatmap to a range 0-255
    heatmap = np.uint8(255 * heatmap)

    # Use jet colormap to colorize heatmap
    jet = cm.get_cmap("jet")

    # Use RGB values of the colormap
    jet_colors = jet(np.arange(256))[:, :3]
    jet_heatmap = jet_colors[heatmap]

    # Create an image with RGB colorized heatmap
    jet_heatmap = tf.keras.preprocessing.image.array_to_img(jet_heatmap)
    jet_heatmap = jet_heatmap.resize((img.shape[1], img.shape[0]))
    jet_heatmap = tf.keras.preprocessing.image.img_to_array(jet_heatmap)

    # Superimpose the heatmap on original image
    superimposed_img = jet_heatmap * alpha + img
    superimposed_img = tf.keras.preprocessing.image.array_to_img(superimposed_img)

    # Save the superimposed image
    superimposed_img.save(cam_path)

    # Display Grad CAM
    # display(Image(cam_path))

    return cam_path
```

```
preprocess_input = tf.keras.applications.mobilenet_v2.preprocess_input
decode_predictions = tf.keras.applications.mobilenet_v2.decode_predictions

last_conv_layer_name = "Conv_1"
img_size = (224,224)

# Remove last layer's softmax
model.layers[-1].activation = None
```

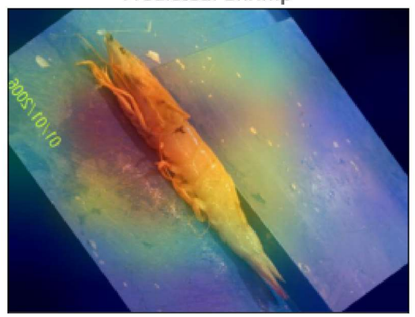
In [19]:

```
# Display the part of the pictures used by the neural network to classify the pictures
fig, axes = plt.subplots(nrows=3, ncols=3, figsize=(15, 10),
                         subplot_kw={'xticks': [], 'yticks': []})

for i, ax in enumerate(axes.flat):
    img_path = test_df.Filepath.iloc[i]
    img_array = preprocess_input(get_img_array(img_path, size=img_size))
    heatmap = make_gradcam_heatmap(img_array, model, last_conv_layer_name)
    cam_path = save_and_display_gradcam(img_path, heatmap)
    ax.imshow(plt.imread(cam_path))
    ax.set_title(f"True: {test_df.Label.iloc[i]}\nPredicted: {pred[i]}")
plt.tight_layout()
plt.show()
```

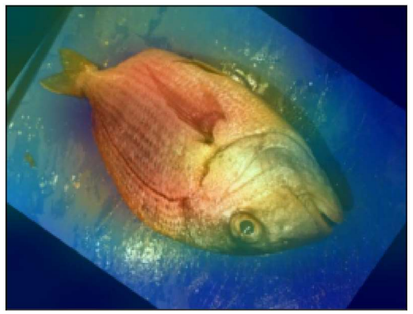
True: Red Sea Bream
Predicted: Red Sea Bream



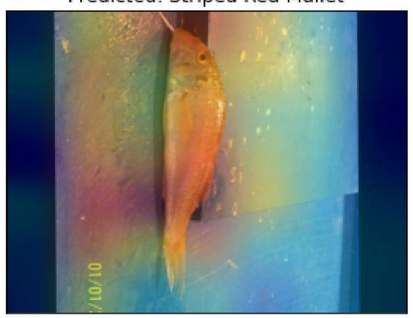
True: Shrimp
Predicted: Shrimp



True: Red Sea Bream
Predicted: Red Sea Bream

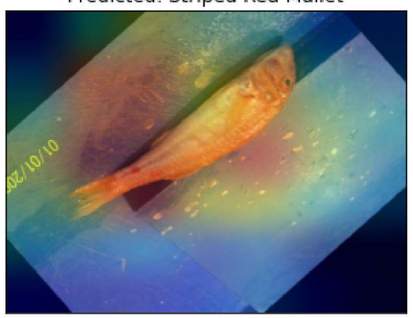


True: Striped Red Mullet
Predicted: Striped Red Mullet



True: Black Sea Sprat
Predicted: Black Sea Sprat

True: Striped Red Mullet
Predicted: Striped Red Mullet



True: Trout
Predicted: Trout

True: Red Sea Bream
Predicted: Red Sea Bream

True: Sea Bass
Predicted: Sea Bass