Classification With Transfer Learning

1 Importing Necessary Libraries

[1]:
```
import os
import numpy as np
import seaborn as sns
import tensorflow as tf
import matplotlib.pyplot as plt
from tensorflow.keras.utils import plot_model
from tensorflow.keras.applications import VGG19
from tensorflow.keras import layers, mixed_precision
from sklearn.metrics import classification_report, confusion_matrix
```

2 Defining Model Architecture (VGG19) and Data Loading

[4]:
```
def cnn(input_shape, num_classes):

    base = VGG19(weights = "imagenet", include_top = False, input_shape =␣
↪input_shape)
    base.trainable = False

    model = tf.keras.Sequential([
        base,
        # layers.GlobalAveragePooling2D(),
        layers.Flatten(),

        layers.Dense(512, activation = "relu"),
        layers.BatchNormalization(),

        layers.Dense(256, activation = "relu"),
        layers.BatchNormalization(),

        layers.Dense(128, activation = "relu"),
        layers.BatchNormalization(),

        layers.Dense(num_classes, activation = "softmax")
    ])
```

```
    return model
```

[6]:
```
dir = "../Dataset/Intel/seg_train"

batch_size = 16
img_h, img_w = 150, 150

train_dataset = tf.keras.utils.image_dataset_from_directory(dir, seed = 100,␣
 ↪image_size = (img_h, img_w), batch_size = batch_size, shuffle = True)
```

```
Found 14034 files belonging to 6 classes.
```

[7]:
```
train_dataset.class_names
```

[7]:
```
['buildings', 'forest', 'glacier', 'mountain', 'sea', 'street']
```

3 Model Initialization

[14]:
```
model = cnn(input_shape = (150, 150, 3), num_classes = 6)
```

3.1 Model Architecture Summary and Visualization

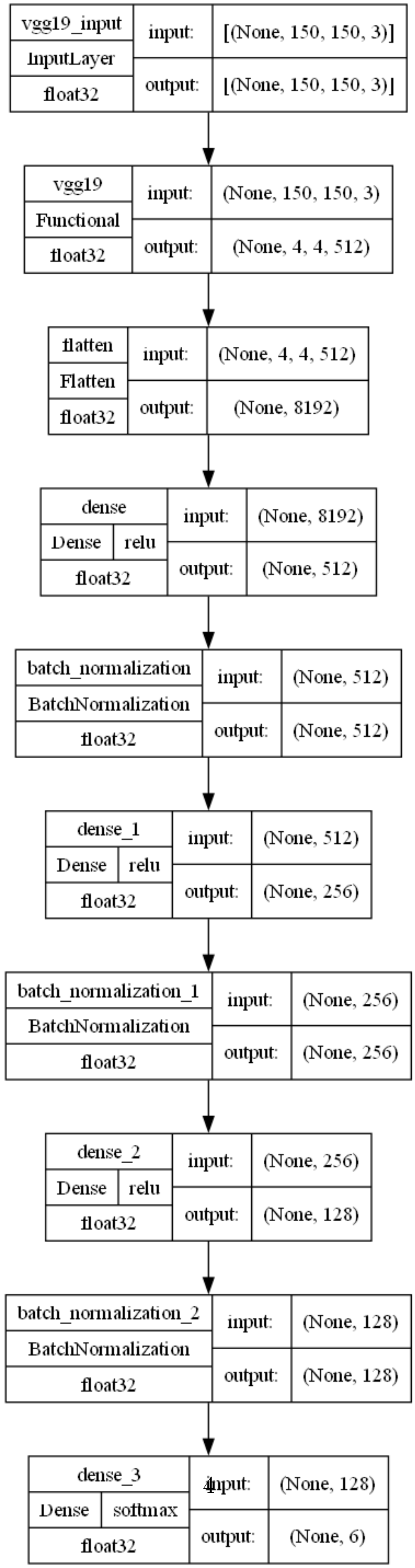
[27]:
```
model.summary()
```

```
Model: "sequential_2"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 vgg19 (Functional)          (None, 4, 4, 512)         20024384

 flatten_2 (Flatten)         (None, 8192)              0

 dense_8 (Dense)             (None, 512)               4194816

 batch_normalization_6 (Batc  (None, 512)              2048
 hNormalization)

 dense_9 (Dense)             (None, 256)               131328

 batch_normalization_7 (Batc  (None, 256)              1024
 hNormalization)

 dense_10 (Dense)            (None, 128)               32896

 batch_normalization_8 (Batc  (None, 128)              512
 hNormalization)
```

```
 dense_11 (Dense)            (None, 6)                 774

=================================================================
Total params: 24,387,782
Trainable params: 4,361,606
Non-trainable params: 20,026,176
_________________________________________________________________
```

[16]:
```
plot_model(model, show_layer_names = True, show_dtype = True,␣
 ↪show_layer_activations = True, show_shapes = True)
```

[16]:


vgg19_input
InputLayer
float32
input:
[(None, 150, 150, 3)]
output:
[(None, 150, 150, 3)]
vgg19
Functional
float32
input:
(None, 150, 150, 3)
output:
(None, 4, 4, 512)
flatten
Flatten
float32
input:
(None, 4, 4, 512)
output:
(None, 8192)
dense
Dense
relu
float32
input:
(None, 8192)
output:
(None, 512)
batch_normalization
BatchNormalization
float32
input:
(None, 512)
output:
(None, 512)
dense_1
Dense
relu
float32
input:
(None, 512)
output:
(None, 256)
batch_normalization_1
BatchNormalization
float32
input:
(None, 256)
output:
(None, 256)
dense_2
Dense
relu
float32
input:
(None, 256)
output:
(None, 128)
batch_normalization_2
BatchNormalization
float32
input:
(None, 128)
output:
(None, 128)
dense_3
Dense
softmax
float32
input:
(None, 128)
output:
(None, 6)

3.2 Training

[29]:
```
model.compile(optimizer = "adam", loss = "sparse_categorical_crossentropy",␣
↪metrics = ["accuracy"])
```

[31]:
```
# Ensure GPU Usage (if you want to use CPU, "/CPU:0")
with tf.device("/GPU:0"):
    history = model.fit(train_dataset, epochs = 20)
```

```
Epoch 1/20
878/878 [==============================] - 116s 125ms/step - loss: 0.4186 -
accuracy: 0.8511
Epoch 2/20
878/878 [==============================] - 94s 107ms/step - loss: 0.2434 -
accuracy: 0.9139
Epoch 3/20
878/878 [==============================] - 98s 111ms/step - loss: 0.1806 -
accuracy: 0.9344
Epoch 4/20
878/878 [==============================] - 94s 107ms/step - loss: 0.1376 -
accuracy: 0.9510
Epoch 5/20
878/878 [==============================] - 67s 77ms/step - loss: 0.1153 -
accuracy: 0.9577
Epoch 6/20
878/878 [==============================] - 68s 77ms/step - loss: 0.0973 -
accuracy: 0.9642
Epoch 7/20
878/878 [==============================] - 68s 77ms/step - loss: 0.0766 -
accuracy: 0.9720
Epoch 8/20
878/878 [==============================] - 68s 78ms/step - loss: 0.0631 -
accuracy: 0.9785
Epoch 9/20
878/878 [==============================] - 68s 78ms/step - loss: 0.0555 -
accuracy: 0.9803
Epoch 10/20
878/878 [==============================] - 70s 79ms/step - loss: 0.0540 -
accuracy: 0.9808
Epoch 11/20
878/878 [==============================] - 71s 81ms/step - loss: 0.0419 -
accuracy: 0.9849
Epoch 12/20
878/878 [==============================] - 40s 46ms/step - loss: 0.0417 -
accuracy: 0.9866
```

```
Epoch 13/20
878/878 [==============================] - 41s 47ms/step - loss: 0.0330 -
accuracy: 0.9889
Epoch 14/20
878/878 [==============================] - 42s 48ms/step - loss: 0.0293 -
accuracy: 0.9900
Epoch 15/20
878/878 [==============================] - 42s 48ms/step - loss: 0.0329 -
accuracy: 0.9885
Epoch 16/20
878/878 [==============================] - 42s 48ms/step - loss: 0.0292 -
accuracy: 0.9905
Epoch 17/20
878/878 [==============================] - 42s 48ms/step - loss: 0.0272 -
accuracy: 0.9912
Epoch 18/20
878/878 [==============================] - 43s 48ms/step - loss: 0.0254 -
accuracy: 0.9911
Epoch 19/20
878/878 [==============================] - 43s 49ms/step - loss: 0.0253 -
accuracy: 0.9917
Epoch 20/20
878/878 [==============================] - 43s 49ms/step - loss: 0.0203 -
accuracy: 0.9932
```

4 Saving The Trained Model

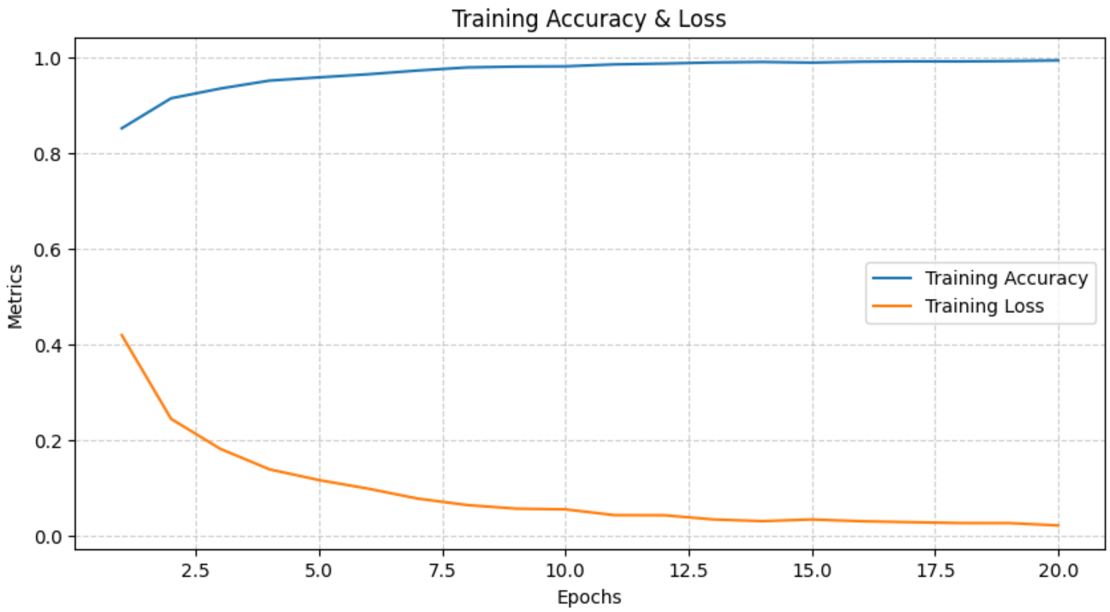
[179]:
```
model.save("../Models/Intel/Model With Transfer Learning.h5")
```

5 Model Evaluation and Other Metrics

5.1 Loss and Accuracy Graphs

[108]:
```
# Plot training accuracy and loss
def plot_loss_accuracy(history):
    acc = history.history['accuracy']
    loss = history.history['loss']

    epochs = range(1, len(acc) + 1)

    plt.figure(figsize=(10, 5))  # Adjust size

    # Plot accuracy and loss on the same graph
    plt.plot(epochs, acc, label='Training Accuracy')  # Blue line with circles
    plt.plot(epochs, loss, label='Training Loss')  # Red line with triangles
```

```
    # Labels & title
    plt.xlabel('Epochs')
    plt.ylabel('Metrics')
    plt.title('Training Accuracy & Loss')

    # Grid and legend
    plt.grid(True, linestyle='--', alpha=0.6)  # Dashed gridlines
    plt.legend()

    plt.show()

plot_loss_accuracy(history)
```



5.2 Confusion Matrix and Classification Report

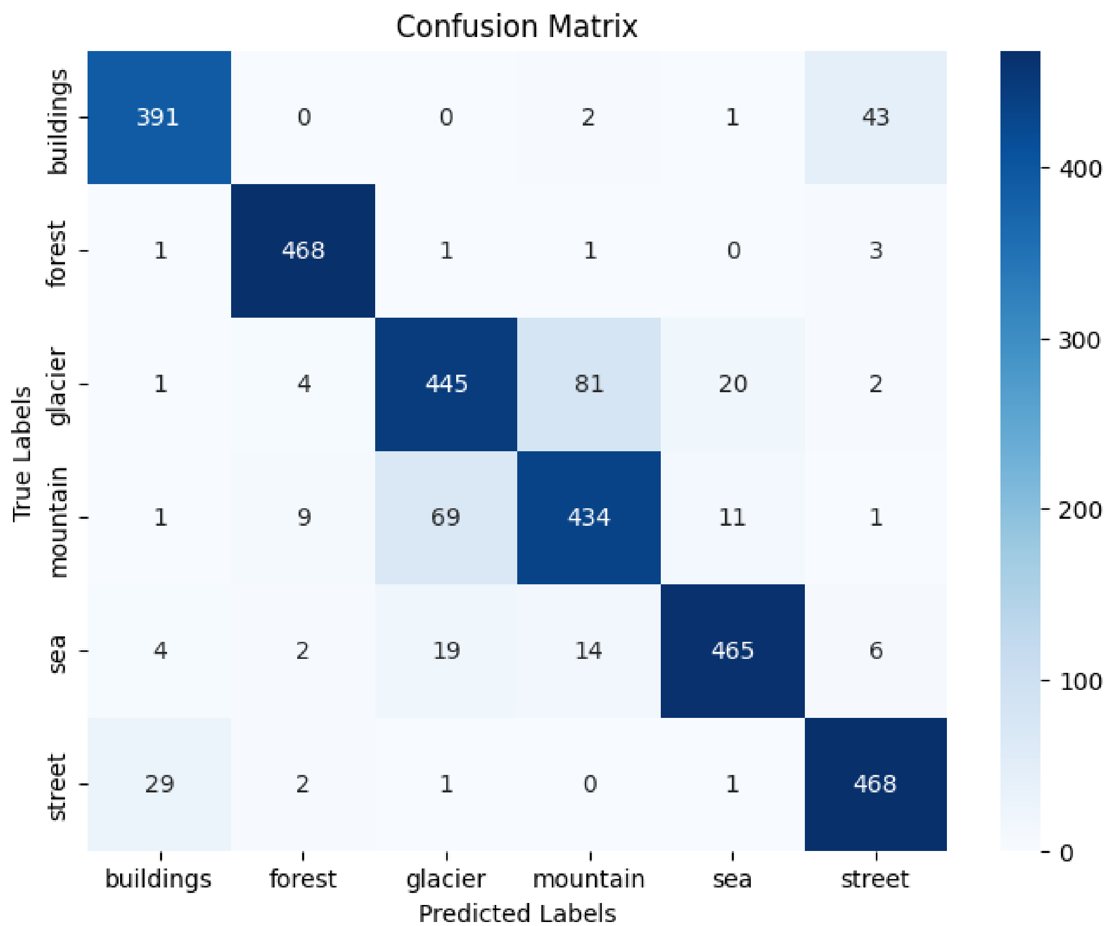
[100]:
```
dir = "../Dataset/Intel/seg_test"

batch_size = 16
img_h, img_w = 150, 150

test_dataset = tf.keras.utils.image_dataset_from_directory(dir, seed = 100,␣
 ↪image_size = (img_h, img_w), batch_size = batch_size, shuffle = False)
```

```
Found 3000 files belonging to 6 classes.
```

[110]:
```
y_true = np.concatenate([labels.numpy() for _, labels in test_dataset])
```

```python
# Get model predictions
y_pred = model.predict(test_dataset)
y_pred_classes = np.argmax(y_pred, axis=1)

# Define class names
class_names = test_dataset.class_names

# Generate Classification Report
print("  Classification Report:\n")
print(classification_report(y_true, y_pred_classes, target_names=class_names))

# Generate Confusion Matrix
cm = confusion_matrix(y_true, y_pred_classes)

# Plot Confusion Matrix
plt.figure(figsize=(8, 6))
sns.heatmap(cm, annot=True, fmt="d", cmap="Blues", xticklabels=class_names,␣
 ↪yticklabels=class_names)
plt.xlabel('Predicted Labels')
plt.ylabel('True Labels')
plt.title('Confusion Matrix')
plt.show()
```

```
188/188 [==============================] - 8s 41ms/step
 Classification Report:

              precision    recall  f1-score   support

   buildings       0.92      0.89      0.91       437
      forest       0.96      0.99      0.98       474
     glacier       0.83      0.80      0.82       553
    mountain       0.82      0.83      0.82       525
         sea       0.93      0.91      0.92       510
      street       0.89      0.93      0.91       501

    accuracy                           0.89      3000
   macro avg       0.89      0.89      0.89      3000
weighted avg       0.89      0.89      0.89      3000
```



6 Inference

6.1 Importing the necessary libraries

[135]:
```
import cv2
import numpy as np
from tensorflow.keras.models import load_model
import matplotlib.pyplot as plt
import random
import math
```

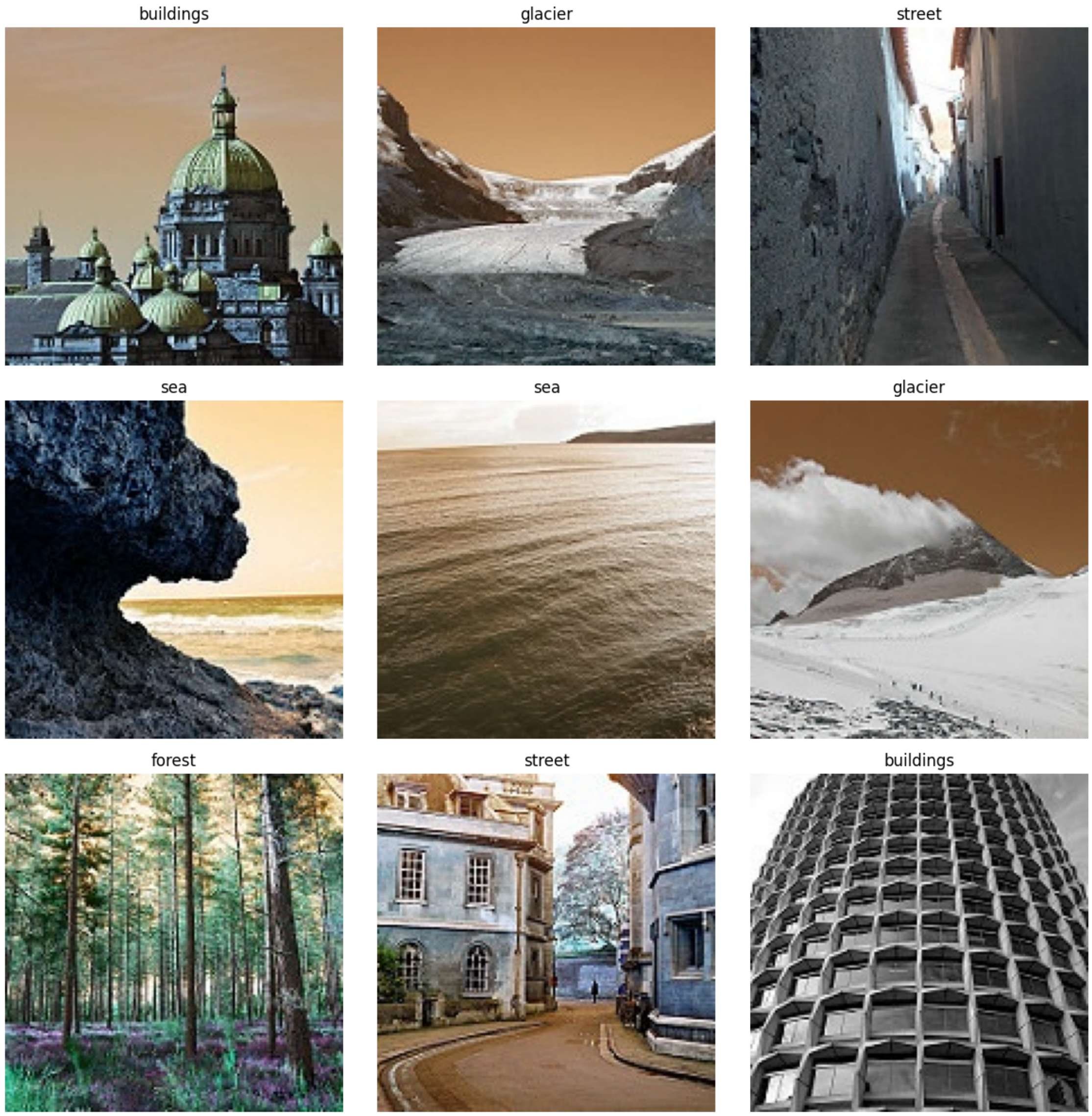
[113]:
```
model = load_model("../Models/Intel/Model With Transfer Learning.h5")
```

[149]:
```
def inference_grid(img_paths, grid_cols=3):
    class_names = ['buildings', 'forest', 'glacier', 'mountain', 'sea',␣
↪'street']
```

```
    num_images = len(img_paths)
    grid_rows = math.ceil(num_images / grid_cols)  # Calculate number of rows␣
 ↪needed

    plt.figure(figsize=(grid_cols * 4, grid_rows * 4))  # Adjust figure size␣
 ↪dynamically

    for i, img_path in enumerate(img_paths):
        img = cv2.imread(img_path)

        # Preprocess image
        img_expanded = np.expand_dims(img, axis=0)

        prediction = model.predict(img_expanded)
        predicted_class = np.argmax(prediction, axis=1)[0]
        predicted_label = class_names[predicted_class]

        # Plot image in a grid
        plt.subplot(grid_rows, grid_cols, i + 1)
        plt.imshow(img)
        plt.axis('off')
        plt.title(f"{predicted_label}", fontsize=12)

    plt.tight_layout()  # Adjust layout for better spacing
    plt.show()
```

[174]:
```
parent_dir = "../Dataset/Intel/seg_pred/"

num_images = 9  # Number of images to predict

img_files = random.sample(os.listdir(parent_dir), num_images)
img_paths = [os.path.join(parent_dir, img) for img in img_files]

inference_grid(img_paths, grid_cols = 3)
```

```
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 18ms/step
```


buildings
glacier
street
sea
sea
glacier
forest
street
buildings