Classification without Transfer Learning

1 Importing Necessary Libraries

[23]:
```
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 and Data Loading

[9]:
```
def cnn(input_shape, num_classes):
    model = tf.keras.Sequential([
        layers.Conv2D(64, (3, 3), activation = "relu", padding = "same",␣
 ↪input_shape = input_shape),
        layers.BatchNormalization(),
        layers.Conv2D(64, (3, 3), activation = "relu", padding = "same"),
        layers.BatchNormalization(),
        layers.MaxPooling2D((2, 2)),

        layers.Conv2D(128, (3, 3), activation = "relu", padding = "same"),
        layers.BatchNormalization(),
        layers.Conv2D(128, (3, 3), activation = "relu", padding = "same"),
        layers.BatchNormalization(),
        layers.MaxPooling2D((2, 2)),


        # Can include these layers for more complexity
        # layers.Conv2D(256, (3, 3), activation = "relu", padding = "same"),
        # layers.BatchNormalization(),
        # layers.Conv2D(256, (3, 3), activation = "relu", padding = "same"),
        # layers.BatchNormalization(),
        # layers.MaxPooling2D((2, 2)),
```

```
        # layers.Conv2D(512, (3, 3), activation = "relu", padding = "same"),
        # layers.BatchNormalization(),
        # layers.Conv2D(512, (3, 3), activation = "relu", padding = "same"),
        # layers.BatchNormalization(),
        # layers.MaxPooling2D((2, 2)),

        # layers.Conv2D(1024, (3, 3), activation = "relu", padding = "same"),
        # layers.BatchNormalization(),
        # layers.Conv2D(1024, (3, 3), activation = "relu", padding = "same"),
        # layers.BatchNormalization(),
        # layers.MaxPooling2D((2, 2)),

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

        layers.Dense(64, activation = "relu"),
        layers.BatchNormalization(),

        layers.Dense(32, activation = "relu"),
        layers.BatchNormalization(),

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

    return model
```

[12]:
```
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.
```

3 Model Initialization

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

3.1 Model Architecture Summary and Visualization

[16]:
```
model.summary()
```

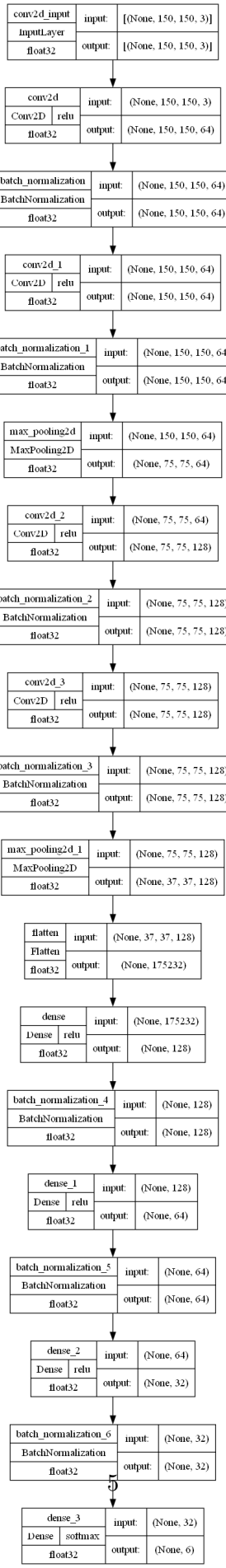
```
Model: "sequential"
_________________________________________________________________
```

```
 Layer (type)                 Output Shape              Param #
=================================================================
 conv2d (Conv2D)              (None, 150, 150, 64)      1792

 batch_normalization (BatchN  (None, 150, 150, 64)     256
 ormalization)

 conv2d_1 (Conv2D)            (None, 150, 150, 64)      36928

 batch_normalization_1 (Batc  (None, 150, 150, 64)     256
 hNormalization)

 max_pooling2d (MaxPooling2D  (None, 75, 75, 64)       0
 )

 conv2d_2 (Conv2D)            (None, 75, 75, 128)       73856

 batch_normalization_2 (Batc  (None, 75, 75, 128)      512
 hNormalization)

 conv2d_3 (Conv2D)            (None, 75, 75, 128)       147584

 batch_normalization_3 (Batc  (None, 75, 75, 128)      512
 hNormalization)

 max_pooling2d_1 (MaxPooling  (None, 37, 37, 128)      0
 2D)

 flatten (Flatten)            (None, 175232)            0

 dense (Dense)                (None, 128)               22429824

 batch_normalization_4 (Batc  (None, 128)              512
 hNormalization)

 dense_1 (Dense)              (None, 64)                8256

 batch_normalization_5 (Batc  (None, 64)               256
 hNormalization)

 dense_2 (Dense)              (None, 32)                2080

 batch_normalization_6 (Batc  (None, 32)               128
 hNormalization)

 dense_3 (Dense)              (None, 6)                 198

=================================================================
```

```
Total params: 22,702,950
Trainable params: 22,701,734
Non-trainable params: 1,216
_________________________________________________________________
```

[25]:
```
plot_model(model, show_layer_names = True, show_dtype = True,␣
  ↪show_layer_activations = True, show_shapes = True)
```

[25]:


conv2d_input | input: | [(None, 150, 150, 3)]
InputLayer | output: | [(None, 150, 150, 3)]
float32
conv2d | input: | (None, 150, 150, 3)
Conv2D | relu | output: | (None, 150, 150, 64)
float32
batch_normalization | input: | (None, 150, 150, 64)
BatchNormalization | output: | (None, 150, 150, 64)
float32
conv2d_1 | input: | (None, 150, 150, 64)
Conv2D | relu | output: | (None, 150, 150, 64)
float32
batch_normalization_1 | input: | (None, 150, 150, 64)
BatchNormalization | output: | (None, 150, 150, 64)
float32
max_pooling2d | input: | (None, 150, 150, 64)
MaxPooling2D | output: | (None, 75, 75, 64)
float32
conv2d_2 | input: | (None, 75, 75, 64)
Conv2D | relu | output: | (None, 75, 75, 128)
float32
batch_normalization_2 | input: | (None, 75, 75, 128)
BatchNormalization | output: | (None, 75, 75, 128)
float32
conv2d_3 | input: | (None, 75, 75, 128)
Conv2D | relu | output: | (None, 75, 75, 128)
float32
batch_normalization_3 | input: | (None, 75, 75, 128)
BatchNormalization | output: | (None, 75, 75, 128)
float32
max_pooling2d_1 | input: | (None, 75, 75, 128)
MaxPooling2D | output: | (None, 37, 37, 128)
float32
flatten | input: | (None, 37, 37, 128)
Flatten | output: | (None, 175232)
float32
dense | input: | (None, 175232)
Dense | relu | output: | (None, 128)
float32
batch_normalization_4 | input: | (None, 128)
BatchNormalization | output: | (None, 128)
float32
dense_1 | input: | (None, 128)
Dense | relu | output: | (None, 64)
float32
batch_normalization_5 | input: | (None, 64)
BatchNormalization | output: | (None, 64)
float32
dense_2 | input: | (None, 64)
Dense | relu | output: | (None, 32)
float32
batch_normalization_6 | input: | (None, 32)
BatchNormalization | output: | (None, 32)
float32
dense_3 | input: | (None, 32)
Dense | softmax | output: | (None, 6)
float32

3.2 Training

[15]:
```
model.compile(optimizer = "adam", loss = "sparse_categorical_crossentropy",␣
↪metrics = ["accuracy"])
```

[17]:
```
with tf.device("/GPU:0"):
    history = model.fit(train_dataset, epochs = 10)
```

```
Epoch 1/10
878/878 [==============================] - 88s 96ms/step - loss: 0.8954 -
accuracy: 0.6638
Epoch 2/10
878/878 [==============================] - 87s 99ms/step - loss: 0.6277 -
accuracy: 0.7701
Epoch 3/10
878/878 [==============================] - 87s 99ms/step - loss: 0.5707 -
accuracy: 0.7959
Epoch 4/10
878/878 [==============================] - 88s 100ms/step - loss: 0.4522 -
accuracy: 0.8353
Epoch 5/10
878/878 [==============================] - 88s 100ms/step - loss: 0.3931 -
accuracy: 0.8603
Epoch 6/10
878/878 [==============================] - 88s 100ms/step - loss: 0.3321 -
accuracy: 0.8826
Epoch 7/10
878/878 [==============================] - 88s 100ms/step - loss: 0.2473 -
accuracy: 0.9147
Epoch 8/10
878/878 [==============================] - 88s 100ms/step - loss: 0.1901 -
accuracy: 0.9329
Epoch 9/10
878/878 [==============================] - 87s 99ms/step - loss: 0.1389 -
accuracy: 0.9528
Epoch 10/10
878/878 [==============================] - 87s 99ms/step - loss: 0.1204 -
accuracy: 0.9605
```

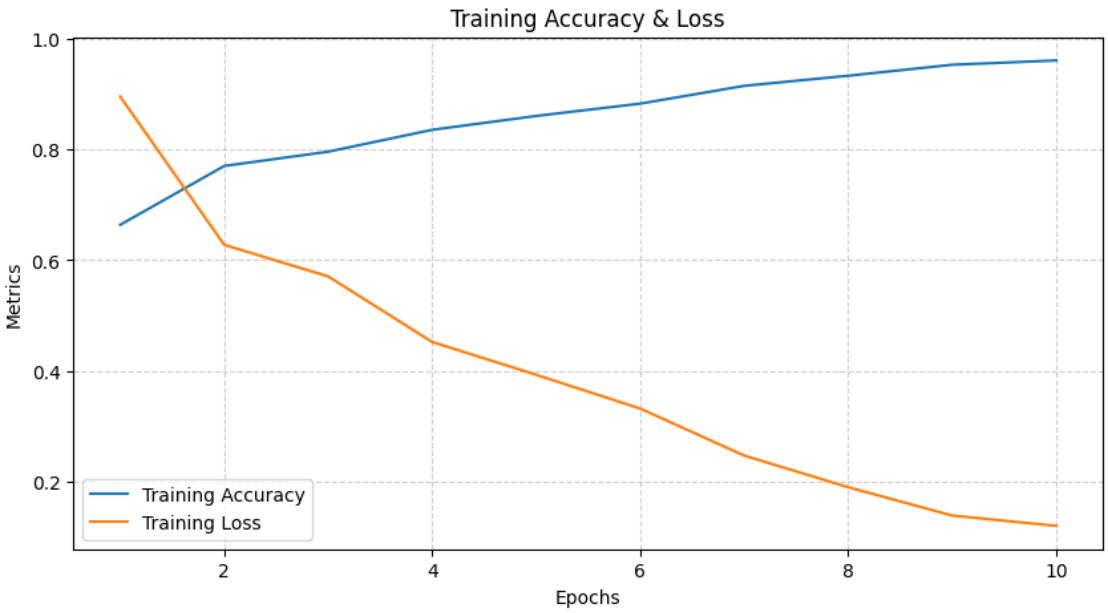
4 Saving The Model

[62]:
```
model.save("../Models/Intel/Model Without Transfer Learning.h5")
```

5 Model Evaluation and Other Metrics

5.1 Loss and Accuracy Graphs

[66]:
```
# 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

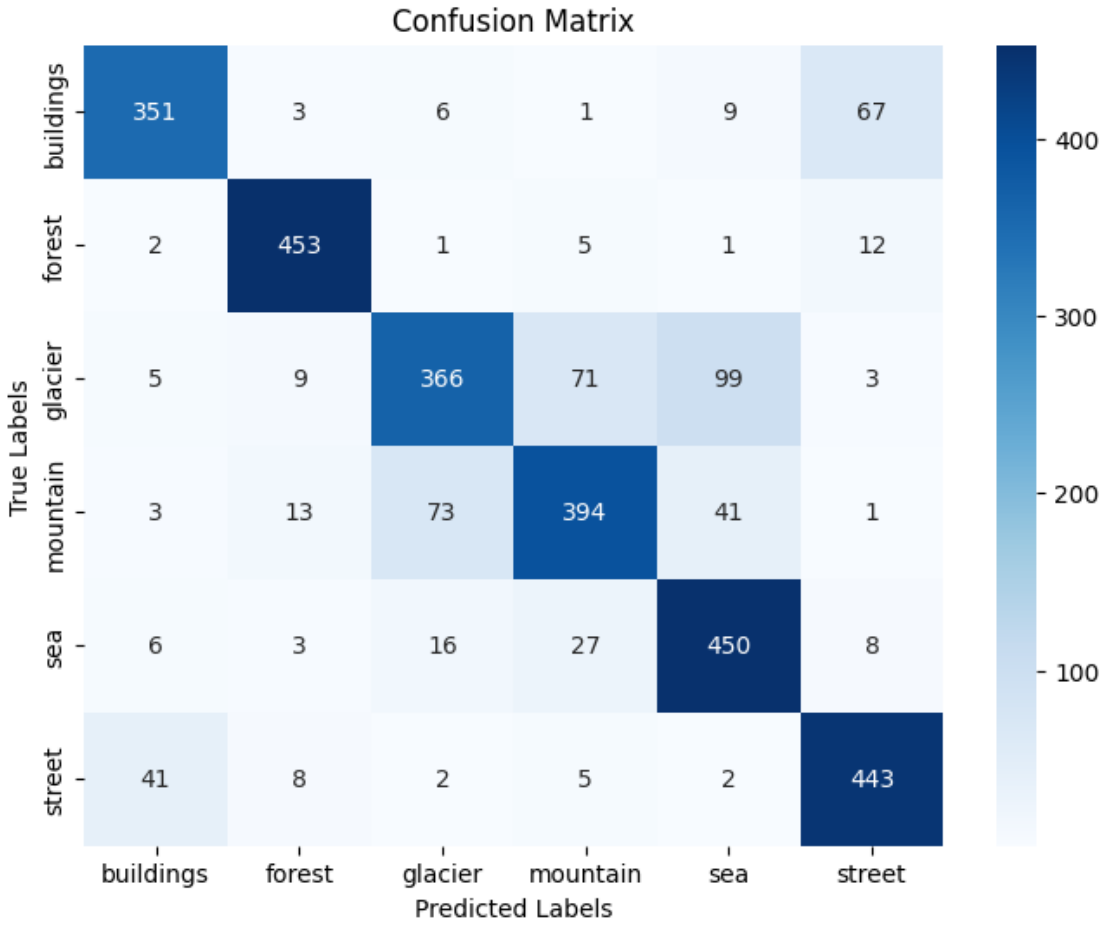
[69]:
```
dir = "../Dataset/Intel/seg_test"

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.
```

[75]:
```
y_true = np.concatenate([labels.numpy() for _, labels in test_dataset])

# 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 [==============================] - 2s 13ms/step
 Classification Report:

              precision    recall  f1-score   support

   buildings       0.86      0.80      0.83       437
      forest       0.93      0.96      0.94       474
     glacier       0.79      0.66      0.72       553
```

```
              precision    recall  f1-score   support

    mountain       0.78      0.75      0.77       525
         sea       0.75      0.88      0.81       510
      street       0.83      0.88      0.86       501

    accuracy                           0.82      3000
   macro avg       0.82      0.82      0.82      3000
weighted avg       0.82      0.82      0.82      3000
```



6 Inference

6.1 Importing the necessary libraries

[52]:
```
import cv2
import numpy as np
from tensorflow.keras.models import load_model
import matplotlib.pyplot as plt
import random
```

```
import math
```

[54]:
```
model = load_model("../Models/Intel/Model Without Transfer Learning.h5")
```

```
INFO:tensorflow:Mixed precision compatibility check (mixed_float16): OK
Your GPU will likely run quickly with dtype policy mixed_float16 as it has
compute capability of at least 7.0. Your GPU: NVIDIA GeForce RTX 4050 Laptop
GPU, compute capability 8.9
```

[56]:
```
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()
```

[60]:
```
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 17ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 16ms/step
```