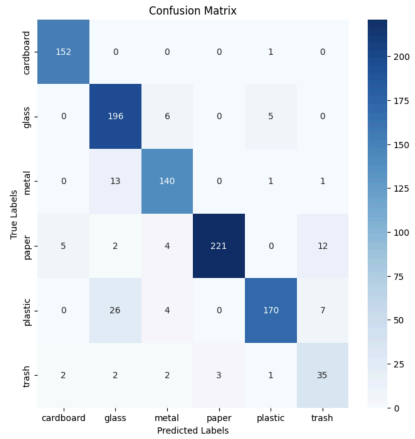
Results Appendix

I. CNN (EfficientNet) Figures

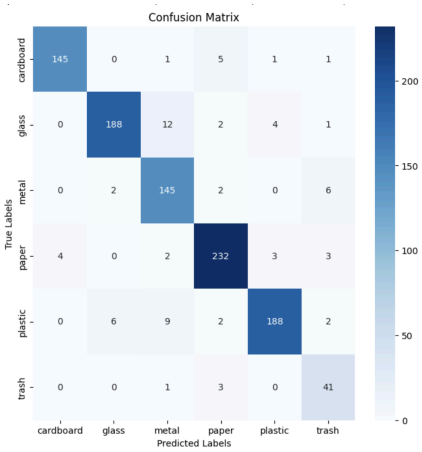
Epoch 1:




```
Classification Report:
              precision    recall  f1-score   support

   cardboard       0.96      0.99      0.97       153
       glass       0.82      0.95      0.88       207
       metal       0.90      0.90      0.90       155
       paper       0.99      0.91      0.94       244
     plastic       0.96      0.82      0.88       207
       trash       0.64      0.78      0.70        45

    accuracy                           0.90      1011
   macro avg       0.88      0.89      0.88      1011
weighted avg       0.91      0.90      0.91      1011
```

```
Epoch 1/4 - Train Loss: 0.5556, Train Acc: 0.8048, Val Loss: 0.2959, Val Acc: 0.9041
```

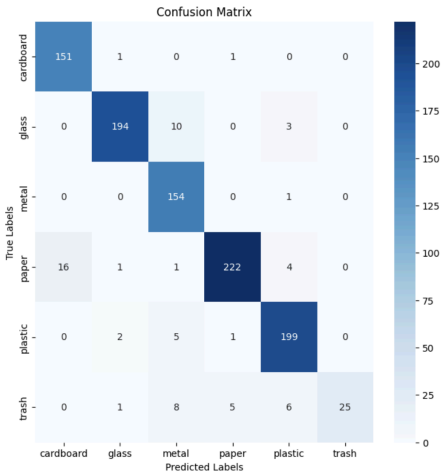
Epoch 2:




```
Classification Report:
              precision    recall  f1-score   support

   cardboard       0.97      0.95      0.96       153
       glass       0.96      0.91      0.93       207
       metal       0.85      0.94      0.89       155
       paper       0.94      0.95      0.95       244
     plastic       0.96      0.91      0.93       207
       trash       0.76      0.91      0.83        45

    accuracy                           0.93      1011
   macro avg       0.91      0.93      0.92      1011
weighted avg       0.93      0.93      0.93      1011
```

```
Epoch 2/4 - Train Loss: 0.3078, Train Acc: 0.9011, Val Loss: 0.2249, Val Acc: 0.9288
```

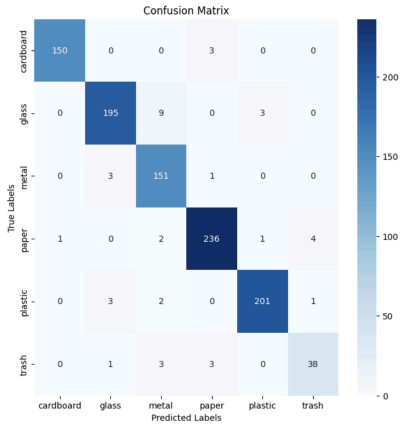
Epoch 3:



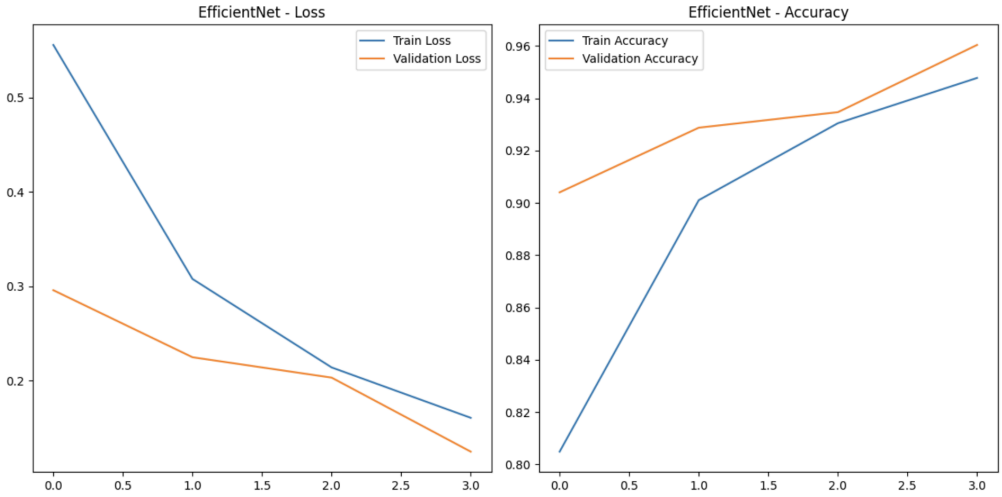

```
Classification Report:
              precision    recall  f1-score   support

   cardboard       0.90      0.99      0.94       153
       glass       0.97      0.94      0.96       207
       metal       0.87      0.99      0.92       155
       paper       0.97      0.91      0.94       244
     plastic       0.93      0.96      0.95       207
       trash       1.00      0.56      0.71        45

    accuracy                           0.93      1011
   macro avg       0.94      0.89      0.90      1011
weighted avg       0.94      0.93      0.93      1011
```

```
Epoch 3/4 - Train Loss: 0.2141, Train Acc: 0.9305, Val Loss: 0.2033, Val Acc: 0.9347
```

Epoch 4:



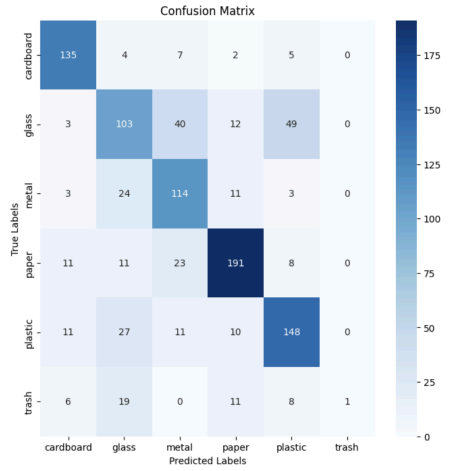

```
Classification Report:
              precision    recall  f1-score   support

   cardboard       0.99      0.98      0.99       153
       glass       0.97      0.94      0.95       207
       metal       0.90      0.97      0.94       155
       paper       0.97      0.97      0.97       244
     plastic       0.98      0.97      0.98       207
       trash       0.88      0.84      0.86        45

    accuracy                           0.96      1011
   macro avg       0.95      0.95      0.95      1011
weighted avg       0.96      0.96      0.96      1011

Epoch 4/4 - Train Loss: 0.1607, Train Acc: 0.9478, Val Loss: 0.1249, Val Acc: 0.9604
```



Over the 4 epochs, the EfficientNet model demonstrated steady improvement, with training accuracy rising from 80.48% to 94.78% and validation accuracy reaching 96.04%. Both training and validation loss consistently decreased, meaning effective convergence without signs of overfitting. The model performed strongly on classes like cardboard, metal, paper, and plastic, achieving high precision, recall, and F1-scores. However, the trash class struggled with lower metrics, particularly recall (56% in Epoch 3, improving to 84% in Epoch 4), maybe due to class imbalance or overlapping features with other categories. The alignment between training and validation metrics highlights good generalization, however performance variability across classes might be due to potential dataset biases. Addressing the underperformance of "trash" by increasing its representation or refining features could further improve results. By Epoch 4, the model appears to have converged, with diminishing returns expected from additional epochs. Overall, the model achieves high accuracy and robust performance, with room for targeted improvements.

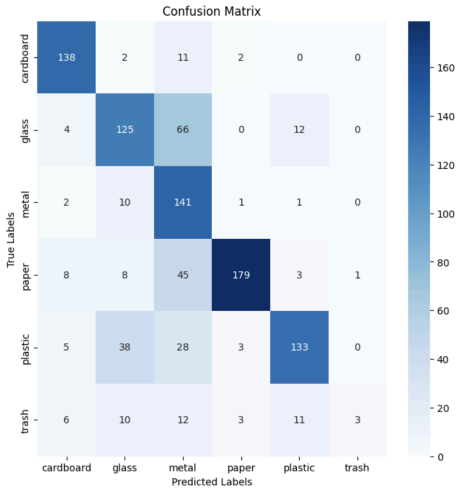
II. CNN (ResNet50) Figures

Epoch 1:



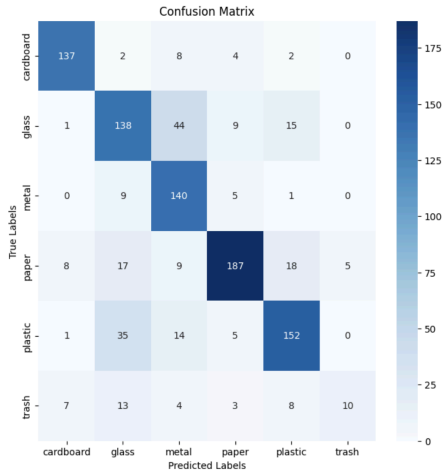

```
Classification Report:
              precision    recall  f1-score   support

   cardboard       0.80      0.88      0.84       153
       glass       0.55      0.50      0.52       207
       metal       0.58      0.74      0.65       155
       paper       0.81      0.78      0.79       244
     plastic       0.67      0.71      0.69       207
       trash       1.00      0.02      0.04        45

    accuracy                           0.68      1011
   macro avg       0.73      0.61      0.59      1011
weighted avg       0.70      0.68      0.67      1011

Epoch 1/4 - Train Loss: 1.1651, Train Acc: 0.5657, Val Loss: 0.8632, Val Acc: 0.6845
```

Epoch 2:



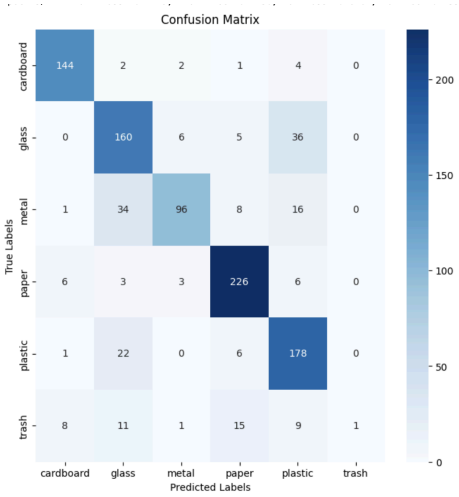

```
Classification Report:
              precision    recall  f1-score   support

   cardboard       0.85      0.90      0.87       153
       glass       0.65      0.60      0.62       207
       metal       0.47      0.91      0.62       155
       paper       0.95      0.73      0.83       244
     plastic       0.83      0.64      0.72       207
       trash       0.75      0.07      0.12        45

    accuracy                           0.71      1011
   macro avg       0.75      0.64      0.63      1011
weighted avg       0.77      0.71      0.71      1011

Epoch 2/4 - Train Loss: 0.8120, Train Acc: 0.6982, Val Loss: 0.8106, Val Acc: 0.7112
```

Epoch 3:

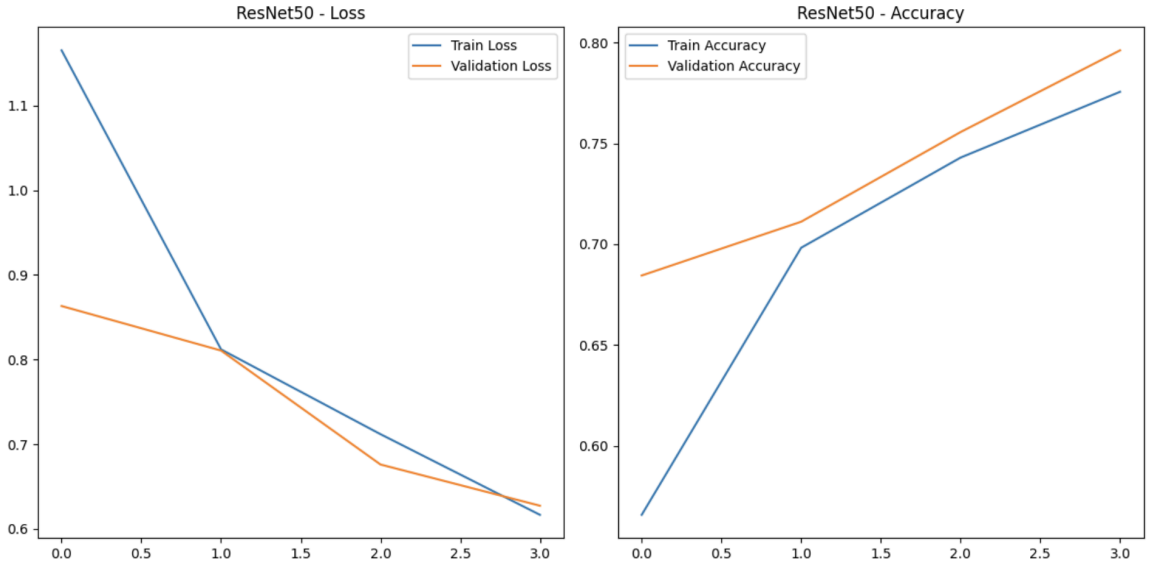



```
Classification Report:
              precision    recall  f1-score   support

   cardboard       0.89      0.90      0.89       153
       glass       0.64      0.67      0.66       207
       metal       0.64      0.90      0.75       155
       paper       0.88      0.77      0.82       244
     plastic       0.78      0.73      0.75       207
       trash       0.67      0.22      0.33        45

    accuracy                           0.76      1011
   macro avg       0.75      0.70      0.70      1011
weighted avg       0.77      0.76      0.75      1011

Epoch 3/4 - Train Loss: 0.7119, Train Acc: 0.7430, Val Loss: 0.6761, Val Acc: 0.7557
```

Epoch 4:




```
Classification Report:
              precision    recall  f1-score   support

   cardboard       0.90      0.94      0.92       153
       glass       0.69      0.77      0.73       207
       metal       0.89      0.62      0.73       155
       paper       0.87      0.93      0.90       244
     plastic       0.71      0.86      0.78       207
       trash       1.00      0.02      0.04        45

    accuracy                           0.80      1011
   macro avg       0.84      0.69      0.68      1011
weighted avg       0.81      0.80      0.78      1011

Epoch 4/4 - Train Loss: 0.6166, Train Acc: 0.7757, Val Loss: 0.6274, Val Acc: 0.7962
```



Over the 4 epochs, the ResNet50 model showed steady improvement in both training and validation metrics. Training accuracy rose from 56.57% in Epoch 1 to 77.57% in Epoch 4, while validation accuracy improved from 68.45% to 79.62%. Similarly, training and validation loss consistently decreased, indicating effective model convergence and improving generalization. The model performed strongly on categories such as cardboard and paper, achieving high precision, recall, and F1-scores by the final epoch. However, categories like trash struggled, with poor recall (as low as 2% in Epoch 1 and remaining at 2% in Epoch 4). While the alignment between training and validation metrics indicates good generalization, there seems to be great variability across classes. By Epoch 4, the model appears to have plateaued, with additional epochs likely yielding minimal performance gains. Overall, ResNet50 demonstrates strong potential for waste classification, but further improvements targeting underperforming classes are necessary to achieve balanced performance across all categories.