Import and Install Required Libraries

```
# =====================================================
# Standard Library
# =====================================================
import os
import sys
import math
import gc
import random
import pickle
from pathlib import Path
from functools import partial
from pprint import pprint
from tqdm import tqdm

# =====================================================
# Third-Party Libraries
# =====================================================
import numpy as np
import pandas as pd
import cv2
import matplotlib.pyplot as plt
import seaborn as sns
import albumentations as A
import joblib

# =====================================================
# TensorFlow / Keras
# =====================================================
import tensorflow as tf
from tensorflow.keras.optimizers import AdamW
from tensorflow.keras import layers, Model, Input, mixed_precision
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense, Dropout, BatchNormalization
from tensorflow.keras.applications import EfficientNetB4
from tensorflow.keras.applications.efficientnet import
preprocess_input
from tensorflow.keras.optimizers import Adam
from tensorflow.keras.callbacks import (
    Callback,
    EarlyStopping,
    ReduceLROnPlateau,
    ModelCheckpoint
)

from tensorflow.keras.utils import to_categorical, custom_object_scope
```

```
# Enable XLA Compilation
tf.config.optimizer.set_jit(True)

# EfficientNetV2S fallback import
try:
    from tensorflow.keras.applications import EfficientNetV2S
except Exception:
    from tensorflow.keras.applications.efficientnet_v2 import
EfficientNetV2S

# =====================================================
# Scikit-Learn
# =====================================================
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler
from sklearn.metrics import (
    accuracy_score,
    f1_score,
    classification_report,
    confusion_matrix,
    precision_score,
    recall_score
)
from sklearn.utils import class_weight
from sklearn.ensemble import GradientBoostingClassifier
from sklearn.linear_model import LogisticRegression
from sklearn.decomposition import PCA
from sklearn.metrics import silhouette_score

# =====================================================
# Mixed Precision
# =====================================================
mixed_precision.set_global_policy("mixed_float16")


# =====================================================
# Train ML Models on GPU
# =====================================================
from cuml.linear_model import LogisticRegression
import cupy as cp
```

Merge Cluster information with Metadata and Verify

```
# Load your original metadata and cluster results
df_meta =
pd.read_csv('/kaggle/input/coral-metrics-and-clusters/metadata.csv')
```

```python
df_clusters =
pd.read_csv('/kaggle/input/coral-metrics-and-clusters/coral_clusters.c
sv')

# Merge cluster information with metadata
df_with_clusters = df_meta.merge(df_clusters, on='image_path',
how='left')

# Verify the merge
print(f"Original metadata shape: {df_meta.shape}")
print(f"Cluster data shape: {df_clusters.shape}")
print(f"Merged data shape: {df_with_clusters.shape}")
print(f"Missing clusters: {df_with_clusters['cluster'].isna().sum()}")

# Display sample with clusters
print("\nSample data with clusters:")
display(df_with_clusters.sample(10))
```

```
Original metadata shape: (39044, 4)
Cluster data shape: (39044, 2)
Merged data shape: (39044, 5)
Missing clusters: 0

Sample data with clusters:

                                              image_path  \
6507   /kaggle/input/coral-condition-dataset/coral_im...
17284  /kaggle/input/coral-condition-dataset/coral_im...
3577   /kaggle/input/coral-condition-dataset/coral_im...
16734  /kaggle/input/coral-condition-dataset/coral_im...
21592  /kaggle/input/coral-condition-dataset/coral_im...
1166   /kaggle/input/coral-condition-dataset/coral_im...
6896   /kaggle/input/coral-condition-dataset/coral_im...
9595   /kaggle/input/coral-condition-dataset/coral_im...
18302  /kaggle/input/coral-condition-dataset/coral_im...
24895  /kaggle/input/coral-condition-dataset/coral_im...

                              filename   folder source  cluster
6507   HWB_0029_12_20230926_0026_31.jpg  clipped    dry        4
17284  SKI_0004_00_20230817_0007_15.jpg  clipped    dry        0
3577   ALK_0030_11_20230927_0059_23.jpg  clipped    dry        2
16734  SKI_0004_00_20230817_0013_33.jpg  clipped    dry        2
21592  CBK_0001_00_20230804_0006_24.jpg  clipped    dry        4
1166   SWP_0025_00_20230919_0010_18.jpg  clipped    dry        2
6896   HWB_0029_12_20230926_0009_26.jpg  clipped    dry        0
9595    HWB_0029_12_20230926_0067_4.jpg  clipped    dry        0
18302  SKI_0004_00_20230817_0095_17.jpg  clipped    dry        2
24895   TCB_0003_00_20230816_0066_8.jpg  clipped    dry        4
```

```
# Check cluster distribution in the merged data
print("\nCluster distribution in merged data:")
df_with_clusters['cluster'].value_counts().sort_index()
```

```
Cluster distribution in merged data:

cluster
0     9379
1     2785
2    14780
3     5175
4     6925
Name: count, dtype: int64
```

```
# Save the enhanced dataset
df_with_clusters.to_csv('/kaggle/working/metadata_with_clusters.csv',
index=False)
print(f"\nSaved enhanced dataset to:
/kaggle/working/metadata_with_clusters.csv")
```

```
Saved enhanced dataset to: /kaggle/working/metadata_with_clusters.csv
```

```
df_with_clusters.info
```

```
<bound method DataFrame.info of
image_path  \
0      /kaggle/input/coral-condition-dataset/coral_im...
1      /kaggle/input/coral-condition-dataset/coral_im...
2      /kaggle/input/coral-condition-dataset/coral_im...
3      /kaggle/input/coral-condition-dataset/coral_im...
4      /kaggle/input/coral-condition-dataset/coral_im...
...                                                  ...
39039  /kaggle/input/coral-condition-dataset/coral_im...
39040  /kaggle/input/coral-condition-dataset/coral_im...
39041  /kaggle/input/coral-condition-dataset/coral_im...
39042  /kaggle/input/coral-condition-dataset/coral_im...
39043  /kaggle/input/coral-condition-dataset/coral_im...

                               filename        folder source  cluster

0         SWP_0025_00_20230919_0020.jpg  20230919_SWP    dry        2

1         SWP_0025_00_20230919_0001.jpg  20230919_SWP    dry        2

2         SWP_0025_00_20230919_0031.jpg  20230919_SWP    dry        2

3         SWP_0025_00_20230919_0022.jpg  20230919_SWP    dry        2

4         SWP_0025_00_20230919_0029.jpg  20230919_SWP    dry        2
```

```
...                                    ...          ...    ...      ...

39039  SKI_0033_00_20240103_0022_11.jpg       cropped    wet        4

39040  SKI_0033_00_20240103_0027_35.jpg       cropped    wet        2

39041   SKI_0033_00_20240103_0007_6.jpg       cropped    wet        1

39042   SKI_0033_00_20240103_0009_5.jpg       cropped    wet        4

39043  SKI_0033_00_20240103_0022_28.jpg       cropped    wet        2


[39044 rows x 5 columns]>
```

```
df_with_clusters.sample(25)
```

```
                                              image_path  \
23096  /kaggle/input/coral-condition-dataset/coral_im...
9117   /kaggle/input/coral-condition-dataset/coral_im...
16294  /kaggle/input/coral-condition-dataset/coral_im...
20053  /kaggle/input/coral-condition-dataset/coral_im...
33907  /kaggle/input/coral-condition-dataset/coral_im...
22624  /kaggle/input/coral-condition-dataset/coral_im...
22384  /kaggle/input/coral-condition-dataset/coral_im...
11200  /kaggle/input/coral-condition-dataset/coral_im...
160    /kaggle/input/coral-condition-dataset/coral_im...
27921  /kaggle/input/coral-condition-dataset/coral_im...
26683  /kaggle/input/coral-condition-dataset/coral_im...
5496   /kaggle/input/coral-condition-dataset/coral_im...
27434  /kaggle/input/coral-condition-dataset/coral_im...
26482  /kaggle/input/coral-condition-dataset/coral_im...
5447   /kaggle/input/coral-condition-dataset/coral_im...
34954  /kaggle/input/coral-condition-dataset/coral_im...
5946   /kaggle/input/coral-condition-dataset/coral_im...
6044   /kaggle/input/coral-condition-dataset/coral_im...
24852  /kaggle/input/coral-condition-dataset/coral_im...
20636  /kaggle/input/coral-condition-dataset/coral_im...
27929  /kaggle/input/coral-condition-dataset/coral_im...
15065  /kaggle/input/coral-condition-dataset/coral_im...
24604  /kaggle/input/coral-condition-dataset/coral_im...
13475  /kaggle/input/coral-condition-dataset/coral_im...
14279  /kaggle/input/coral-condition-dataset/coral_im...

                               filename        folder source  cluster

23096  TCB_0003_00_20230816_0097_14.jpg       clipped    dry        1

9117   HWB_0029_12_20230926_0019_20.jpg       clipped    dry        2
```

```
16294  SKI_0004_00_20230817_0057_19.jpg       clipped    dry        4
20053   SKI_0004_00_20230817_0013_7.jpg       clipped    dry        2
33907  CBK_0038_00_20240124_0035_24.jpg       cropped    wet        2
22624  TCB_0003_00_20230816_0095_15.jpg       clipped    dry        1
22384     TCB_0003_00_20230816_0063.jpg  20230816_TCB    dry        2
11200  HNM_0031_00_20230928_0012_34.jpg       clipped    dry        3
160    SWP_0025_00_20230919_0037_24.jpg       clipped    dry        2
27921  HWB_0037_12_20240122_0066_15.jpg       cropped    wet        3
26683  HWB_0037_12_20240122_0044_34.jpg       cropped    wet        3
5496               20230412_0003_13.jpg       clipped    dry        3
27434  HWB_0037_12_20240122_0008_28.jpg       cropped    wet        2
26482   HWB_0037_12_20240122_0053_3.jpg       cropped    wet        4
5447               20230412_0030_11.jpg       clipped    dry        3
34954  CBK_0038_00_20240124_0068_21.jpg       cropped    wet        2
5946                20230412_0021_2.jpg       clipped    dry        2
6044               20230412_0008_19.jpg       clipped    dry        0
24852  TCB_0003_00_20230816_0039_14.jpg       clipped    dry        4
20636  CBK_0001_00_20230804_0081_23.jpg       clipped    dry        4
27929   HWB_0037_12_20240122_0043_1.jpg       cropped    wet        2
15065  TTB_0002_00_20230815_0008_33.jpg       clipped    dry        0
24604  TCB_0003_00_20230816_0005_21.jpg       clipped    dry        4
13475  HNM_0031_00_20230928_0042_19.jpg       clipped    dry        2
14279  AOM_0032_00_20230929_0009_12.jpg       clipped    dry        2
```

Merge cluster metrics

```
# Add cluster color metrics information
metrics_df =
pd.read_csv('/kaggle/input/coral-metrics-and-clusters/cluster_color_me
trics.csv')

# Rename columns to distinguish cluster-level metrics
metrics_df_renamed = metrics_df.rename(columns={
    'mean_brightness': 'cluster_mean_brightness',
    'mean_saturation': 'cluster_mean_saturation',
    'mean_luminance_std': 'cluster_mean_luminance_std'
}).drop('n_images', axis=1)  # Drop n_images as it's redundant

# Merge cluster metrics
df_complete = df_with_clusters.merge(metrics_df_renamed, on='cluster',
how='left')

print(f"Complete dataset shape: {df_complete.shape}")
print("\nColumns in complete dataset:")
df_complete.columns.tolist()
```

```
Complete dataset shape: (39044, 8)

Columns in complete dataset:
```

```
['image_path',
 'filename',
 'folder',
 'source',
 'cluster',
 'cluster_mean_brightness',
 'cluster_mean_saturation',
 'cluster_mean_luminance_std']
```

```
# Save the complete analysis dataset
df_complete.to_csv('/kaggle/working/coral_dataset_with_clusters_and_me
trics.csv', index=False)
print(f"\nSaved complete dataset to:
/kaggle/working/coral_dataset_with_clusters_and_metrics.csv")
```

```


Saved complete dataset to:
/kaggle/working/coral_dataset_with_clusters_and_metrics.csv
```

```
df_complete.sample(25)
```

```
                                              image_path  \
26946  /kaggle/input/coral-condition-dataset/coral_im...
31124  /kaggle/input/coral-condition-dataset/coral_im...
38084  /kaggle/input/coral-condition-dataset/coral_im...
6686   /kaggle/input/coral-condition-dataset/coral_im...
9550   /kaggle/input/coral-condition-dataset/coral_im...
7680   /kaggle/input/coral-condition-dataset/coral_im...
28434  /kaggle/input/coral-condition-dataset/coral_im...
```

```
26935  /kaggle/input/coral-condition-dataset/coral_im...
38736  /kaggle/input/coral-condition-dataset/coral_im...
19156  /kaggle/input/coral-condition-dataset/coral_im...
24651  /kaggle/input/coral-condition-dataset/coral_im...
13300  /kaggle/input/coral-condition-dataset/coral_im...
2435   /kaggle/input/coral-condition-dataset/coral_im...
29311  /kaggle/input/coral-condition-dataset/coral_im...
761    /kaggle/input/coral-condition-dataset/coral_im...
16624  /kaggle/input/coral-condition-dataset/coral_im...
37196  /kaggle/input/coral-condition-dataset/coral_im...
22263  /kaggle/input/coral-condition-dataset/coral_im...
23     /kaggle/input/coral-condition-dataset/coral_im...
28824  /kaggle/input/coral-condition-dataset/coral_im...
10559  /kaggle/input/coral-condition-dataset/coral_im...
16318  /kaggle/input/coral-condition-dataset/coral_im...
20710  /kaggle/input/coral-condition-dataset/coral_im...
23568  /kaggle/input/coral-condition-dataset/coral_im...
38624  /kaggle/input/coral-condition-dataset/coral_im...

                               filename             folder source
cluster  \
26946  HWB_0037_12_20240122_0021_21.jpg            cropped    wet
4
31124  ALK_0035_00_20240118_0017_21.jpg            cropped    wet
2
38084     SKI_0033_00_20240103_0012.jpg  20240103_SKI_done    wet
2
6686   HWB_0029_12_20230926_0084_12.jpg            clipped    dry
0
9550   HWB_0029_12_20230926_0035_26.jpg            clipped    dry
4
7680   HWB_0029_12_20230926_0058_18.jpg            clipped    dry
2
28434  HWB_0037_12_20240122_0071_27.jpg            cropped    wet
0
26935  HWB_0037_12_20240122_0043_18.jpg            cropped    wet
2
38736  SKI_0033_00_20240103_0013_13.jpg            cropped    wet
4
19156  SKI_0004_00_20230817_0080_13.jpg            clipped    dry
2
24651  TCB_0003_00_20230816_0076_22.jpg            clipped    dry
3
13300  HNM_0031_00_20230928_0075_14.jpg            clipped    dry
3
2435   ALK_0030_11_20230927_0029_19.jpg            clipped    dry
2
29311   SIN_0040_00_20240129_0052_4.jpg            cropped    wet
4
```

```
761    SWP_0025_00_20230919_0010_12.jpg            clipped    dry
2
16624   SKI_0004_00_20230817_0018_9.jpg            clipped    dry
2
37196  CBK_0039_00_20240126_0026_12.jpg            cropped    wet
2
22263  CBK_0001_00_20230804_0069_28.jpg            clipped    dry
4
23        SWP_0025_00_20230919_0025.jpg       20230919_SWP    dry
2
28824  HWB_0037_12_20240122_0052_17.jpg            cropped    wet
4
10559  HWB_0029_12_20230926_0068_28.jpg            clipped    dry
0
16318  SKI_0004_00_20230817_0016_10.jpg            clipped    dry
0
20710   CBK_0001_00_20230804_0017_4.jpg            clipped    dry
4
23568  TCB_0003_00_20230816_0084_17.jpg            clipped    dry
2
38624   SKI_0033_00_20240103_0022_6.jpg            cropped    wet
4

       cluster_mean_brightness  cluster_mean_saturation  \
26946                 0.498285                 0.275200
31124                 0.346147                 0.331251
38084                 0.346147                 0.331251
6686                  0.213652                 0.430153
9550                  0.498285                 0.275200
7680                  0.346147                 0.331251
28434                 0.213652                 0.430153
26935                 0.346147                 0.331251
38736                 0.498285                 0.275200
19156                 0.346147                 0.331251
24651                 0.439220                 0.337231
13300                 0.439220                 0.337231
2435                  0.346147                 0.331251
29311                 0.498285                 0.275200
761                   0.346147                 0.331251
16624                 0.346147                 0.331251
37196                 0.346147                 0.331251
22263                 0.498285                 0.275200
23                    0.346147                 0.331251
28824                 0.498285                 0.275200
10559                 0.213652                 0.430153
16318                 0.213652                 0.430153
20710                 0.498285                 0.275200
23568                 0.346147                 0.331251
38624                 0.498285                 0.275200
```

```
       cluster_mean_luminance_std
26946                    0.147476
31124                    0.143388
38084                    0.143388
6686                     0.107641
9550                     0.147476
7680                     0.143388
28434                    0.107641
26935                    0.143388
38736                    0.147476
19156                    0.143388
24651                    0.129777
13300                    0.129777
2435                     0.143388
29311                    0.147476
761                      0.143388
16624                    0.143388
37196                    0.143388
22263                    0.147476
23                       0.143388
28824                    0.147476
10559                    0.107641
16318                    0.107641
20710                    0.147476
23568                    0.143388
38624                    0.147476
```

Cross-tabulation: clusters vs sources

```
# Cross-tabulation: clusters vs sources
cluster_source_ct = pd.crosstab(df_with_clusters['cluster'],
df_with_clusters['source'])
print("Cluster distribution across dry/wet sources:")
cluster_source_ct
```

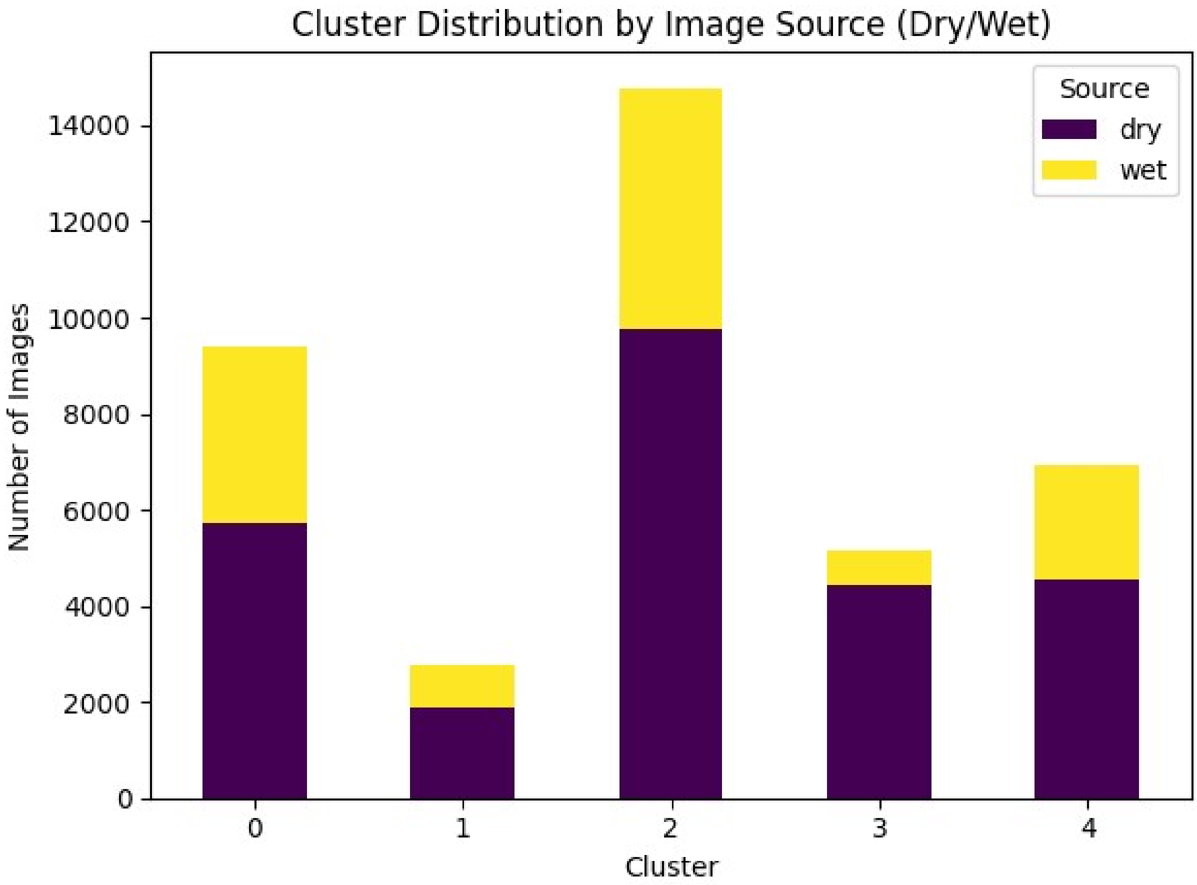
```
Cluster distribution across dry/wet sources:
```

```
source    dry   wet
cluster
0        5704  3675
1        1888   897
2        9744  5036
3        4423   752
4        4541  2384
```

Cross-tabulation: clusters vs folders

```
cluster_folder_ct = pd.crosstab(df_with_clusters['cluster'],
df_with_clusters['folder'])
print("\nTop folders in each cluster (showing top 5 folders per
cluster):")
for cluster_id in sorted(df_with_clusters['cluster'].unique()):
    cluster_data = df_with_clusters[df_with_clusters['cluster'] ==
cluster_id]
    top_folders = cluster_data['folder'].value_counts().head(5)
    print(f"\nCluster {cluster_id}:")
    for folder, count in top_folders.items():
        print(f"  {folder}: {count} images")
```

```

Top folders in each cluster (showing top 5 folders per cluster):

Cluster 0:
  clipped: 5694 images
  cropped: 3655 images
  20240118_ALK_done: 8 images
  20240126_CBK_done: 6 images
  20230926_HWB: 4 images

Cluster 1:
  clipped: 1877 images
  cropped: 895 images
  20230804_CBK: 11 images
  20240119_SKI_done: 1 images
  20240103_SKI_done: 1 images

Cluster 2:
  clipped: 9251 images
  cropped: 4751 images
  20230817_SKI: 101 images
  20230926_HWB: 100 images
  20230816_TCB: 99 images

Cluster 3:
  clipped: 4299 images
  cropped: 738 images
  20230927_ALK: 29 images
  20230928_HNM: 24 images
  20230421_preliminary_survey: 22 images

Cluster 4:
  clipped: 4425 images
  cropped: 2351 images
  20230804_CBK: 59 images
  20230817_SKI: 36 images
  20240103_SKI_done: 15 images

# Visualization: Cluster distribution by source
plt.figure(figsize=(10, 6))
cluster_source_ct.plot(kind='bar', stacked=True, colormap='viridis')
plt.title('Cluster Distribution by Image Source (Dry/Wet)')
plt.xlabel('Cluster')
plt.ylabel('Number of Images')
plt.legend(title='Source')
plt.xticks(rotation=0)
plt.tight_layout()
plt.savefig('/kaggle/working/cluster_distribution_by_source.png',
dpi=200)
plt.show()

<Figure size 1000x600 with 0 Axes>
```



Data Preparation and Splitting

```
# Prepare data
X =
np.load('/kaggle/input/coral-metrics-and-clusters/coral_features.npy')

df_complete =
pd.read_csv('/kaggle/working/coral_dataset_with_clusters_and_metrics.csv')

# Use clusters as labels (since you want to predict/validate clusters)
y = df_complete['cluster'].values

# Split data - stratify to maintain cluster distribution
X_train, X_temp, y_train, y_temp = train_test_split(
    X, y, test_size=0.3, random_state=42, stratify=y
)
X_val, X_test, y_val, y_test = train_test_split(
    X_temp, y_temp, test_size=0.5, random_state=42, stratify=y_temp
)

print(f"Training set: {X_train.shape[0]} samples")
print(f"Validation set: {X_val.shape[0]} samples")
print(f"Test set: {X_test.shape[0]} samples")

# Convert labels to categorical for neural network
num_classes = len(np.unique(y))
y_train_cat = to_categorical(y_train, num_classes=num_classes)
y_val_cat = to_categorical(y_val, num_classes=num_classes)
y_test_cat = to_categorical(y_test, num_classes=num_classes)
```

```
Training set: 27330 samples
Validation set: 5857 samples
Test set: 5857 samples
```

Build a Simple Neural Network Classifier

```
def create_simple_nn_model(input_dim, num_classes):
    model = Sequential([
        Dense(512, activation='relu', input_shape=(input_dim,)),
        BatchNormalization(),
        Dropout(0.3),

        Dense(256, activation='relu'),
        BatchNormalization(),
        Dropout(0.3),

        Dense(128, activation='relu'),
        BatchNormalization(),
        Dropout(0.2),

        Dense(64, activation='relu'),
        Dropout(0.2),

        Dense(num_classes, activation='softmax')
    ])

    return model

# Create model
model = create_simple_nn_model(X.shape[1], num_classes)
model.compile(
    optimizer=Adam(learning_rate=0.001),
    loss='categorical_crossentropy',
    metrics=['accuracy']
)

model.summary()
```

```
/usr/local/lib/python3.11/dist-packages/keras/src/layers/core/
dense.py:87: UserWarning: Do not pass an `input_shape`/`input_dim`
argument to a layer. When using Sequential models, prefer using an
`Input(shape)` object as the first layer in the model instead.
  super().__init__(activity_regularizer=activity_regularizer,
**kwargs)
I0000 00:00:1763861220.951818      48 gpu_device.cc:2022] Created
device /job:localhost/replica:0/task:0/device:GPU:0 with 13942 MB
memory:  -> device: 0, name: Tesla T4, pci bus id: 0000:00:04.0,
compute capability: 7.5
I0000 00:00:1763861220.952610      48 gpu_device.cc:2022] Created
device /job:localhost/replica:0/task:0/device:GPU:1 with 13942 MB
memory:  -> device: 1, name: Tesla T4, pci bus id: 0000:00:05.0,
compute capability: 7.5
```

```
Model: "sequential"

┏━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━┳━━━━━━━━━━━━━━━━━━━━━━━━┳━━━━━━━━━━
━━━━━┓
┃ Layer (type)                    ┃ Output Shape           ┃
Param # ┃
┡━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━╇━━━━━━━━━━━━━━━━━━━━━━━━╇━━━━━━━━━━
━━━━━┩
│ dense (Dense)                   │ (None, 512)            │
655,872 │
├─────────────────────────────────┼────────────────────────┼──────────
─────┤
│ batch_normalization             │ (None, 512)            │
2,048 │
```

```
│ (BatchNormalization)            │                        │
│
├─────────────────────────────────┼────────────────────────┼──────────
─────┤
│ dropout (Dropout)               │ (None, 512)            │
0 │
├─────────────────────────────────┼────────────────────────┼──────────
─────┤
│ dense_1 (Dense)                 │ (None, 256)            │
131,328 │
├─────────────────────────────────┼────────────────────────┼──────────
─────┤
│ batch_normalization_1           │ (None, 256)            │
1,024 │
│ (BatchNormalization)            │                        │
│
├─────────────────────────────────┼────────────────────────┼──────────
─────┤
│ dropout_1 (Dropout)             │ (None, 256)            │
0 │
├─────────────────────────────────┼────────────────────────┼──────────
─────┤
│ dense_2 (Dense)                 │ (None, 128)            │
32,896 │
├─────────────────────────────────┼────────────────────────┼──────────
─────┤
│ batch_normalization_2           │ (None, 128)            │
512 │
│ (BatchNormalization)            │                        │
│
├─────────────────────────────────┼────────────────────────┼──────────
─────┤
│ dropout_2 (Dropout)             │ (None, 128)            │
0 │
├─────────────────────────────────┼────────────────────────┼──────────
─────┤
│ dense_3 (Dense)                 │ (None, 64)             │
8,256 │
├─────────────────────────────────┼────────────────────────┼──────────
─────┤
│ dropout_3 (Dropout)             │ (None, 64)             │
0 │
├─────────────────────────────────┼────────────────────────┼──────────
─────┤
│ dense_4 (Dense)                 │ (None, 5)              │
325 │
└─────────────────────────────────┴────────────────────────┴──────────
─────┘

 Total params: 832,261 (3.17 MB)
 Trainable params: 830,469 (3.17 MB)

 Non-trainable params: 1,792 (7.00 KB)
```

Train with Callbacks for Efficient GPU Usage

```
# Callbacks to prevent overfitting and optimize training
callbacks = [
    EarlyStopping(monitor='val_loss', patience=10,
restore_best_weights=True),
    ReduceLROnPlateau(monitor='val_loss', factor=0.5, patience=5,
min_lr=1e-7),
    tf.keras.callbacks.ModelCheckpoint(
        '/kaggle/working/simple_nn_classifier.h5',
        monitor='val_accuracy',
        save_best_only=True,
        mode='max'
    )
]

# Train the model
history = model.fit(
    X_train, y_train_cat,
    batch_size=128,  # Adjust based on GPU memory
    epochs=100,
    validation_data=(X_val, y_val_cat),
    callbacks=callbacks,
    verbose=1
)
```

```
Epoch 1/100

WARNING: All log messages before absl::InitializeLog() is called are
written to STDERR
I0000 00:00:1763861225.083611     122 service.cc:148] XLA service
0x7b85680074a0 initialized for platform CUDA (this does not guarantee
that XLA will be used). Devices:
I0000 00:00:1763861225.085052     122 service.cc:156]   StreamExecutor
device (0): Tesla T4, Compute Capability 7.5
I0000 00:00:1763861225.085071     122 service.cc:156]   StreamExecutor
device (1): Tesla T4, Compute Capability 7.5
I0000 00:00:1763861225.147231     122 cuda_dnn.cc:529] Loaded cuDNN
version 90300
I0000 00:00:1763861225.288806     122 device_compiler.h:188] Compiled
cluster using XLA!  This line is logged at most once for the lifetime
of the process.

214/214 ━━━━━━━━━━━━━━━━━━━━ 0s 25ms/step - accuracy: 0.3159 - loss:
1.5968
```

```
WARNING:absl:You are saving your model as an HDF5 file via
`model.save()` or `keras.saving.save_model(model)`. This file format
is considered legacy. We recommend using instead the native Keras
format, e.g. `model.save('my_model.keras')` or
`keras.saving.save_model(model, 'my_model.keras')`.

214/214 ━━━━━━━━━━━━━━━━━━━━ 15s 32ms/step - accuracy: 0.3164 - loss:
1.5962 - val_accuracy: 0.3785 - val_loss: 1.4988 - learning_rate:
0.0010
Epoch 2/100
214/214 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.5154 - loss:
1.2922 - val_accuracy: 0.3765 - val_loss: 1.5079 - learning_rate:
0.0010
Epoch 3/100
214/214 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.5445 - loss:
1.2418 - val_accuracy: 0.3348 - val_loss: 1.4166 - learning_rate:
0.0010
Epoch 4/100
214/214 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.5548 - loss:
1.2231 - val_accuracy: 0.2566 - val_loss: 1.6214 - learning_rate:
0.0010
Epoch 5/100
206/214 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.5542 - loss:
1.2211

WARNING:absl:You are saving your model as an HDF5 file via
`model.save()` or `keras.saving.save_model(model)`. This file format
is considered legacy. We recommend using instead the native Keras
format, e.g. `model.save('my_model.keras')` or
`keras.saving.save_model(model, 'my_model.keras')`.

214/214 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.5545 - loss:
1.2209 - val_accuracy: 0.3935 - val_loss: 2.1431 - learning_rate:
0.0010
Epoch 6/100
204/214 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.5711 - loss:
1.2021

WARNING:absl:You are saving your model as an HDF5 file via
`model.save()` or `keras.saving.save_model(model)`. This file format
is considered legacy. We recommend using instead the native Keras
format, e.g. `model.save('my_model.keras')` or
`keras.saving.save_model(model, 'my_model.keras')`.

214/214 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.5708 - loss:
1.2022 - val_accuracy: 0.4439 - val_loss: 1.5558 - learning_rate:
0.0010
Epoch 7/100
214/214 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.5725 - loss:
1.1940 - val_accuracy: 0.2290 - val_loss: 1.5583 - learning_rate:
```

```
0.0010
Epoch 8/100
214/214 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.5652 - loss:
1.2117 - val_accuracy: 0.3483 - val_loss: 1.3937 - learning_rate:
0.0010
Epoch 9/100
214/214 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.5770 - loss:
1.1926 - val_accuracy: 0.2691 - val_loss: 1.5440 - learning_rate:
0.0010
Epoch 10/100
214/214 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.5749 - loss:
1.1969 - val_accuracy: 0.1059 - val_loss: 1.8392 - learning_rate:
0.0010
Epoch 11/100
214/214 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.5802 - loss:
1.1857 - val_accuracy: 0.3550 - val_loss: 1.4103 - learning_rate:
0.0010
Epoch 12/100
214/214 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.5702 - loss:
1.2028 - val_accuracy: 0.1636 - val_loss: 1.6293 - learning_rate:
0.0010
Epoch 13/100
214/214 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.5716 - loss:
1.1939 - val_accuracy: 0.2969 - val_loss: 1.4467 - learning_rate:
0.0010
Epoch 14/100
205/214 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.5801 - loss:
1.1836

WARNING:absl:You are saving your model as an HDF5 file via
`model.save()` or `keras.saving.save_model(model)`. This file format
is considered legacy. We recommend using instead the native Keras
format, e.g. `model.save('my_model.keras')` or
`keras.saving.save_model(model, 'my_model.keras')`.

214/214 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.5800 - loss:
1.1837 - val_accuracy: 0.4762 - val_loss: 1.3186 - learning_rate:
5.0000e-04
Epoch 15/100
214/214 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.5786 - loss:
1.1852 - val_accuracy: 0.3222 - val_loss: 1.4703 - learning_rate:
5.0000e-04
Epoch 16/100
214/214 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.5851 - loss:
1.1813 - val_accuracy: 0.4458 - val_loss: 1.3346 - learning_rate:
5.0000e-04
Epoch 17/100
214/214 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.5858 - loss:
1.1773 - val_accuracy: 0.2040 - val_loss: 1.6585 - learning_rate:
5.0000e-04
```

```
Epoch 18/100
205/214 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.5795 - loss:
1.1861

WARNING:absl:You are saving your model as an HDF5 file via
`model.save()` or `keras.saving.save_model(model)`. This file format
is considered legacy. We recommend using instead the native Keras
format, e.g. `model.save('my_model.keras')` or
`keras.saving.save_model(model, 'my_model.keras')`.

214/214 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.5796 - loss:
1.1859 - val_accuracy: 0.5155 - val_loss: 1.2298 - learning_rate:
5.0000e-04
Epoch 19/100
214/214 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.5876 - loss:
1.1731 - val_accuracy: 0.3486 - val_loss: 1.4320 - learning_rate:
5.0000e-04
Epoch 20/100
203/214 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.5820 - loss:
1.1800

WARNING:absl:You are saving your model as an HDF5 file via
`model.save()` or `keras.saving.save_model(model)`. This file format
is considered legacy. We recommend using instead the native Keras
format, e.g. `model.save('my_model.keras')` or
`keras.saving.save_model(model, 'my_model.keras')`.

214/214 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.5819 - loss:
1.1803 - val_accuracy: 0.5419 - val_loss: 1.2123 - learning_rate:
5.0000e-04
Epoch 21/100
214/214 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.5788 - loss:
1.1834 - val_accuracy: 0.4832 - val_loss: 1.3342 - learning_rate:
5.0000e-04
Epoch 22/100
214/214 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.5878 - loss:
1.1811 - val_accuracy: 0.3893 - val_loss: 1.4068 - learning_rate:
5.0000e-04
Epoch 23/100
214/214 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.5850 - loss:
1.1854 - val_accuracy: 0.5242 - val_loss: 1.2324 - learning_rate:
5.0000e-04
Epoch 24/100
214/214 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.5886 - loss:
1.1736 - val_accuracy: 0.4400 - val_loss: 1.4004 - learning_rate:
5.0000e-04
Epoch 25/100
214/214 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.5859 - loss:
1.1725 - val_accuracy: 0.3620 - val_loss: 1.5085 - learning_rate:
5.0000e-04
```

```
Epoch 26/100
214/214 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.5801 - loss:
1.1852 - val_accuracy: 0.5296 - val_loss: 1.2378 - learning_rate:
2.5000e-04
Epoch 27/100
214/214 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.5891 - loss:
1.1727 - val_accuracy: 0.5250 - val_loss: 1.2430 - learning_rate:
2.5000e-04
Epoch 28/100
214/214 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.5933 - loss:
1.1605 - val_accuracy: 0.4924 - val_loss: 1.2837 - learning_rate:
2.5000e-04
Epoch 29/100
205/214 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.5855 - loss:
1.1676

WARNING:absl:You are saving your model as an HDF5 file via
`model.save()` or `keras.saving.save_model(model)`. This file format
is considered legacy. We recommend using instead the native Keras
format, e.g. `model.save('my_model.keras')` or
`keras.saving.save_model(model, 'my_model.keras')`.

214/214 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.5854 - loss:
1.1681 - val_accuracy: 0.5542 - val_loss: 1.2031 - learning_rate:
2.5000e-04
Epoch 30/100
205/214 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.5848 - loss:
1.1785

WARNING:absl:You are saving your model as an HDF5 file via
`model.save()` or `keras.saving.save_model(model)`. This file format
is considered legacy. We recommend using instead the native Keras
format, e.g. `model.save('my_model.keras')` or
`keras.saving.save_model(model, 'my_model.keras')`.

214/214 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.5849 - loss:
1.1784 - val_accuracy: 0.6104 - val_loss: 1.1583 - learning_rate:
2.5000e-04
Epoch 31/100
214/214 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.5857 - loss:
1.1730 - val_accuracy: 0.5977 - val_loss: 1.1598 - learning_rate:
2.5000e-04
Epoch 32/100
214/214 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.5868 - loss:
1.1758 - val_accuracy: 0.4605 - val_loss: 1.2976 - learning_rate:
2.5000e-04
Epoch 33/100
214/214 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.5885 - loss:
1.1702 - val_accuracy: 0.4195 - val_loss: 1.3751 - learning_rate:
2.5000e-04
```

```
Epoch 34/100
214/214 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.5856 - loss:
1.1731 - val_accuracy: 0.4420 - val_loss: 1.3492 - learning_rate:
2.5000e-04
Epoch 35/100
214/214 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.5833 - loss:
1.1795 - val_accuracy: 0.5498 - val_loss: 1.2213 - learning_rate:
2.5000e-04
Epoch 36/100
214/214 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.5836 - loss:
1.1798 - val_accuracy: 0.5945 - val_loss: 1.1611 - learning_rate:
1.2500e-04
Epoch 37/100
214/214 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.5856 - loss:
1.1715 - val_accuracy: 0.5197 - val_loss: 1.2398 - learning_rate:
1.2500e-04
Epoch 38/100
214/214 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.5865 - loss:
1.1784 - val_accuracy: 0.5137 - val_loss: 1.2424 - learning_rate:
1.2500e-04
Epoch 39/100
214/214 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.5885 - loss:
1.1662 - val_accuracy: 0.5516 - val_loss: 1.2353 - learning_rate:
1.2500e-04
Epoch 40/100
214/214 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.5856 - loss:
1.1738 - val_accuracy: 0.5189 - val_loss: 1.2419 - learning_rate:
1.2500e-04
```

Comprehensive Model Evaluation

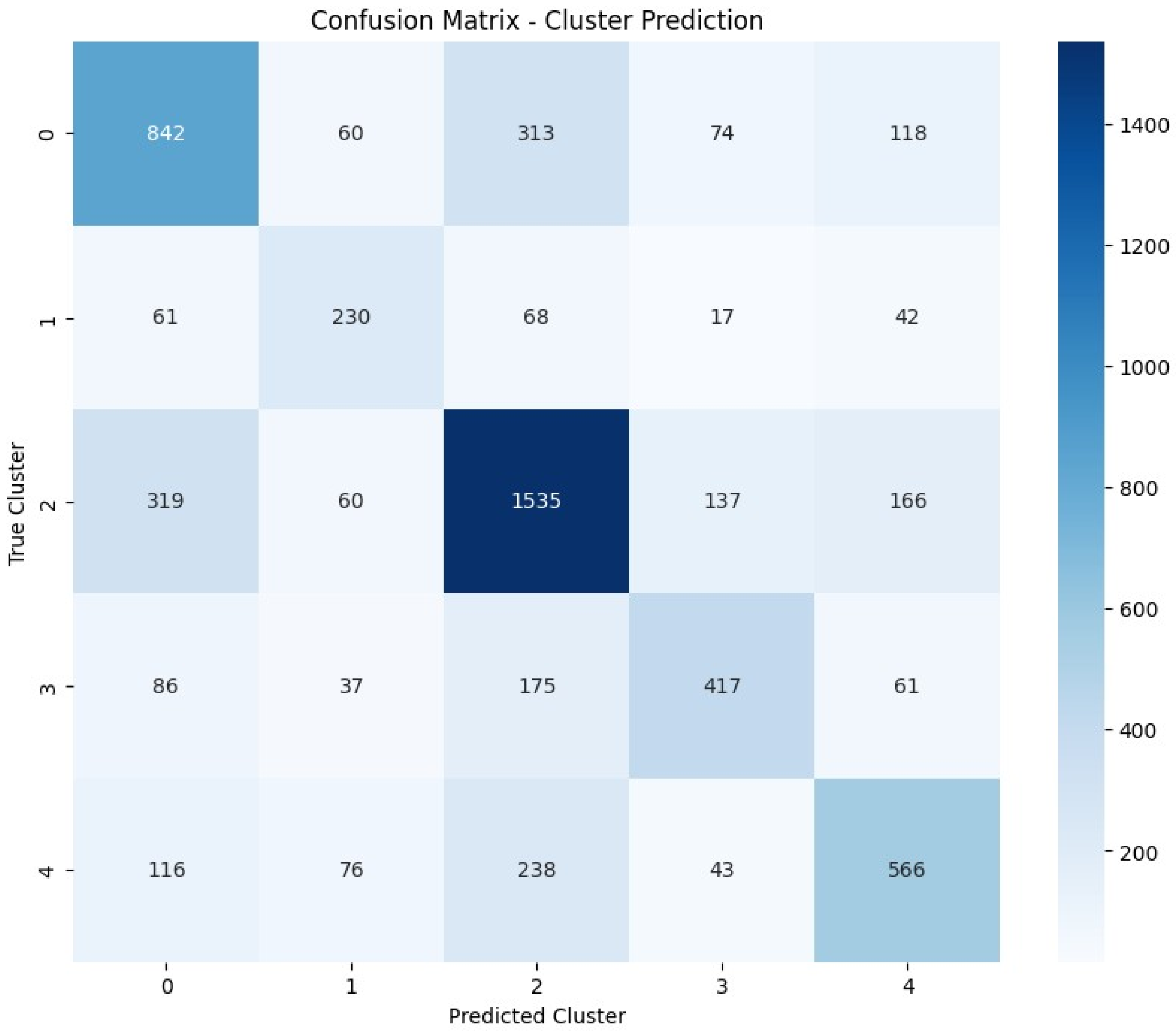
```
# Load the Simple NN Classifier trained model
model.load_weights('/kaggle/working/simple_nn_classifier.h5')

# Predictions
y_pred_proba = model.predict(X_test)
y_pred = np.argmax(y_pred_proba, axis=1)
```

```
184/184 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step
```

```
# Classification Report
print("Classification Report of Simple NN Model:")
print(classification_report(y_test, y_pred))
```

```
Classification Report of Simple NN Model:
              precision    recall  f1-score   support

           0       0.59      0.60      0.59      1407
           1       0.50      0.55      0.52       418
           2       0.66      0.69      0.68      2217
           3       0.61      0.54      0.57       776
           4       0.59      0.54      0.57      1039

    accuracy                           0.61      5857
   macro avg       0.59      0.58      0.59      5857
weighted avg       0.61      0.61      0.61      5857
```

```
# Confusion Matrix
plt.figure(figsize=(10, 8))
cm = confusion_matrix(y_test, y_pred)
sns.heatmap(cm, annot=True, fmt='d', cmap='Blues')
plt.title('Confusion Matrix - Cluster Prediction')
plt.ylabel('True Cluster')
plt.xlabel('Predicted Cluster')
plt.savefig('/kaggle/working/confusion_matrix.png', dpi=200)
plt.show()
```



Load the Previous Pipeline Outputs obtained from the Actual Data

```
# ----------------------------
# Robust pipeline using your existing outputs
# - Uses precomputed features + cluster labels as targets when no
human labels exist
# - Trains: (A) Feature-based classifier (fast) (B) Image-based fine-
tuned EfficientNetV2-S (strong)
# - Saves artifacts to /kaggle/working/
# ----------------------------
# ---- Paths (these are the outputs you saved earlier) ----
WORK = Path("/kaggle/working")
INPUT = Path("/kaggle/input/coral-metrics-and-clusters")
```

```
features_fp = INPUT / "coral_features.npy"
valid_paths_fp = INPUT / "valid_paths.csv"
clusters_fp = INPUT / "coral_clusters.csv"
metadata_fp = INPUT / "metadata.csv"
cluster_metrics_fp = INPUT / "cluster_color_metrics.csv"
tsne_fp = INPUT / "tsne_results.npy"

# Check files presence
for p in [features_fp, valid_paths_fp, clusters_fp]:
    if not p.exists():
        raise FileNotFoundError(f"Required file not found: {p}. This
script expects the files you produced earlier.")

print("Found required outputs.")
```

```
Found required outputs.
```

```
# Load
features = np.load(str(features_fp))
valid_paths = pd.read_csv(str(valid_paths_fp))['image_path'].tolist()
df_clusters = pd.read_csv(str(clusters_fp))

print("Features shape:", features.shape)
print("Valid paths len:", len(valid_paths))
print("Clusters shape:", df_clusters.shape)
```

```
Features shape: (39044, 1280)
Valid paths len: 39044
Clusters shape: (39044, 2)
```

```
# Map: image_path -> cluster label
df_clusters_map = df_clusters.set_index('image_path')
['cluster'].to_dict()
# Build dataset aligned to features list
aligned_labels = []
aligned_paths = []
for p in valid_paths:
    if p in df_clusters_map:
        aligned_labels.append(int(df_clusters_map[p]))
        aligned_paths.append(p)
    else:
        # fallback: skip if missing
        aligned_labels.append(-1)
        aligned_paths.append(p)
aligned_labels = np.array(aligned_labels)
# Remove any -1 entries (shouldn't happen given your earlier pipeline)
keep_mask = aligned_labels >= 0
features = features[keep_mask]
aligned_labels = aligned_labels[keep_mask]
aligned_paths = [p for i,p in enumerate(aligned_paths) if
keep_mask[i]]

print("Aligned features:", features.shape, "Aligned labels:",
aligned_labels.shape)
```

```
Aligned features: (39044, 1280) Aligned labels: (39044,)
```

```
# Quick stats
n_classes = int(aligned_labels.max()) + 1
print("Pseudo-targets: clustering yielded", n_classes, "classes.")
print(pd.Series(aligned_labels).value_counts().sort_index())
```

```
Pseudo-targets: clustering yielded 5 classes.
0     9379
1     2785
2    14780
3     5175
4     6925
Name: count, dtype: int64
```

Baseline Traditional ML Model Training and Evaluation (Logistic Regression using GPU)

```
# ----------------------------
# 1) Baseline: Feature-based classifier (fast, strong)
# We'll train a simple pipeline (StandardScaler + LogisticRegression)
# ----------------------------
print("\n=== TRAIN: Feature-based classifier ===")
X = features
y = aligned_labels
```

```

=== TRAIN: Feature-based classifier ===
```

```
# split
X_train, X_val, y_train, y_val = train_test_split(X, y,
test_size=0.18, random_state=42, stratify=y)

# Scale
scaler = StandardScaler()
X_train_s = scaler.fit_transform(X_train)
X_val_s = scaler.transform(X_val)

# Move data to GPU
X_train_gpu = cp.asarray(X_train_s)
y_train_gpu = cp.asarray(y_train)

MAX_ITERS = 1000
```

```python
print("Training LogisticRegression on GPU with single progress
bar...")

# Progress bar (time-based approximation)
pbar = tqdm(total=MAX_ITERS, desc="GPU Logistic Regression",
unit="iter")

# Start fit in background
model = LogisticRegression(max_iter=MAX_ITERS)
model.fit(X_train_gpu, y_train_gpu)

# Update the bar to 100%
pbar.update(MAX_ITERS)
pbar.close()
```

```
Training LogisticRegression on GPU with single progress bar...


GPU Logistic Regression:   0%|          | 0/1000 [00:14<?, ?iter/s]

[2025-11-23 01:34:48.164] [CUML] [warning] L-BFGS: max iterations
reached
[2025-11-23 01:34:48.165] [CUML] [warning] Maximum iterations reached
before solver is converged. To increase model accuracy you can
increase the number of iterations (max_iter) or improve the scaling of
the input data.
```

```python
# --------------------------
# Validation Predictions (GPU -> CPU)
# --------------------------
X_val_gpu = cp.asarray(X_val_s)
y_pred_gpu = model.predict(X_val_gpu)
yv_lr = cp.asnumpy(y_pred_gpu)

# --------------------------
# Metrics
# --------------------------
print("LR val acc:", accuracy_score(y_val, yv_lr))
print("macro F1:", f1_score(y_val, yv_lr, average='macro'))

print("\nLogistic Regression Classification Report:")
print(classification_report(y_val, yv_lr))
```

```
LR val acc: 0.9883323847467274
macro F1: 0.9855681895094073

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

```
           0       0.99      0.99      0.99      1688
           1       0.98      0.98      0.98       501
           2       0.99      0.99      0.99      2660
           3       0.98      0.98      0.98       932
           4       0.99      0.98      0.99      1247

    accuracy                           0.99      7028
   macro avg       0.99      0.98      0.99      7028
weighted avg       0.99      0.99      0.99      7028
```

```
# Save baseline
joblib.dump(
    {
        'scaler': scaler,
        'model_params': model.get_params()
    },
    WORK / "feature_logreg_pipeline.joblib"
)

print("Saved scaler and logistic regression params.")
```

```
Saved scaler and logistic regression params.
```

Image-based EfficientNetV2-S Model Training, Finetuning and Evaluation

```
# ------------------------------
# Strong image-based model (EfficientNetV2-S -> train to predict clusters)
# Use cluster labels as pseudo-targets so you obtain an image model ready for later re-training with true labels
# ------------------------------
print("\n=== TRAIN: Image-based EfficientNetV2-S (predicting cluster IDs as targets) ===")

# prepare labels in one-hot for categorical crossentropy
y_onehot = to_categorical(aligned_labels, num_classes=n_classes)

# train/val split aligned with features -> reuse indices
# We'll compute indices from aligned_paths; create map of path->index for train_test_split earlier
# Simple way: resplit using the same seed and stratify:
# train/val split
train_idx, val_idx = train_test_split(
    range(len(aligned_paths)),
    test_size=0.18,
    random_state=42,
    stratify=aligned_labels
)
train_paths = [aligned_paths[i] for i in train_idx]
val_paths = [aligned_paths[i] for i in val_idx]
y_train = y_onehot[train_idx]
y_val = y_onehot[val_idx]

print("Train images:", len(train_paths), "Val images:",
len(val_paths))
```

```
=== TRAIN: Image-based EfficientNetV2-S (predicting cluster IDs as
targets) ===
Train images: 32016 Val images: 7028
```

Pipeline Preparation for Image Model Training

```
# ----------------------------
# Dataset pipeline
# ----------------------------
IMG_SIZE = 384
BATCH = 24
AUTOTUNE = tf.data.AUTOTUNE

def preprocess_image(path, label, training=True):
    # pure TF ops
    img = tf.io.read_file(path)
    img = tf.image.decode_jpeg(img, channels=3)
    img = tf.image.convert_image_dtype(img, tf.float32)

    if training:
        # First resize to >= IMG_SIZE
        img = tf.image.resize(img, [IMG_SIZE + 20, IMG_SIZE + 20])

        # Now safe to crop
        img = tf.image.random_crop(img, [IMG_SIZE, IMG_SIZE, 3])

        img = tf.image.random_flip_left_right(img)
        img = tf.image.random_flip_up_down(img)
        img = tf.image.random_brightness(img, 0.08)
        img = tf.image.random_contrast(img, 0.9, 1.1)
    else:
        img = tf.image.resize(img, [IMG_SIZE, IMG_SIZE])

    # EfficientNet scaling
    img = (img - 0.5) * 2.0
    # Ensure float32
    label = tf.cast(label, tf.float32)

    return img, label

def make_ds(paths, labels, training=True, batch=BATCH):
    ds = tf.data.Dataset.from_tensor_slices((paths, labels))
    if training:
        ds = ds.shuffle(4096)

    ds = ds.map(
        lambda p, l: preprocess_image(p, l, training),
        num_parallel_calls=AUTOTUNE
    )

    # ds = ds.batch(batch).prefetch(AUTOTUNE)
    ds = ds.batch(batch)
    ds = ds.prefetch(AUTOTUNE)
    return ds

train_ds = make_ds(train_paths, y_train, training=True)
val_ds   = make_ds(val_paths,  y_val, training=False)
```

Build EfficientnetV2S Model, Freeze backbone, Train Head and Evaluation

```
def build_image_model(num_classes):
    inp = Input(shape=(IMG_SIZE, IMG_SIZE, 3), name='image')
    base = EfficientNetV2S(include_top=False, weights='imagenet',
input_tensor=inp, pooling='avg')
    x = base.output
    x = layers.Dropout(0.35)(x)
    x = layers.Dense(512, activation='relu')(x)
    x = layers.BatchNormalization()(x)
    x = layers.Dropout(0.25)(x)
    out = layers.Dense(num_classes, activation='softmax',
dtype='float32')(x)
    model = Model(inp, out)
    return model


img_model = build_image_model(n_classes)
img_model.summary()
```

```
Model: "functional"

┏━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━┳━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━┳━━━━━━━━━━━━━━━━━━━━━━━━┳━━━━━━━━━━━━━━━━━━━━━━━━━━━
━━━━━━━━┓
```

```
┃ Layer (type)         ┃ Output Shape       ┃     Param # ┃ Connected to
┃
┡━━━━━━━━━━━━━━━━━━━━━━╇━━━━━━━━━━━━━━━━━━━━╇━━━━━━━━━━━━━╇━━━━━━━━━━━━━━
━━━━━┩
│ image (InputLayer)   │ (None, 384, 384,   │           0 │ -
│
│                      │ 3)                 │             │
│
├──────────────────────┼────────────────────┼─────────────┼──────────────
─────┤
│ rescaling            │ (None, 384, 384,   │           0 │ image[0][0]
│
│ (Rescaling)          │ 3)                 │             │
│
├──────────────────────┼────────────────────┼─────────────┼──────────────
─────┤
│ stem_conv (Conv2D)   │ (None, 192, 192,   │         648 │ rescaling[0]
[0]    │
│                      │ 24)                │             │
│
├──────────────────────┼────────────────────┼─────────────┼──────────────
─────┤
│ stem_bn              │ (None, 192, 192,   │          96 │ stem_conv[0]
[0]    │
│ (BatchNormalizatio…  │ 24)                │             │
│
├──────────────────────┼────────────────────┼─────────────┼──────────────
─────┤
│ stem_activation      │ (None, 192, 192,   │           0 │ stem_bn[0][0]
│
│ (Activation)         │ 24)                │             │
│
├──────────────────────┼────────────────────┼─────────────┼──────────────
─────┤
│ block1a_project_co…  │ (None, 192, 192,   │       5,184 │
stem_activation[… │
│ (Conv2D)             │ 24)                │             │
│
├──────────────────────┼────────────────────┼─────────────┼──────────────
─────┤
│ block1a_project_bn   │ (None, 192, 192,   │          96 │
block1a_project_… │
│ (BatchNormalizatio…  │ 24)                │             │
│
├──────────────────────┼────────────────────┼─────────────┼──────────────
─────┤
│ block1a_project_ac…  │ (None, 192, 192,   │           0 │
block1a_project_… │
│ (Activation)         │ 24)                │             │
```

```
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block1a_add (Add)   │ (None, 192, 192,  │          0 │
block1a_project_… │
│                     │ 24)               │            │
stem_activation[… │
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block1b_project_co… │ (None, 192, 192,  │      5,184 │
block1a_add[0][0] │
│ (Conv2D)            │ 24)               │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block1b_project_bn  │ (None, 192, 192,  │         96 │
block1b_project_… │
│ (BatchNormalizatio… │ 24)               │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block1b_project_ac… │ (None, 192, 192,  │          0 │
block1b_project_… │
│ (Activation)        │ 24)               │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block1b_drop        │ (None, 192, 192,  │          0 │
block1b_project_… │
│ (Dropout)           │ 24)               │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block1b_add (Add)   │ (None, 192, 192,  │          0 │
block1b_drop[0][… │
│                     │ 24)               │            │
block1a_add[0][0] │
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block2a_expand_conv │ (None, 96, 96,    │     20,736 │
block1b_add[0][0] │
│ (Conv2D)            │ 96)               │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block2a_expand_bn   │ (None, 96, 96,    │        384 │
block2a_expand_c… │
│ (BatchNormalizatio… │ 96)               │            │
│
```

```
├──────────────────────┼────────────────────┼─────────────┼──────────────
─────┤
│ block2a_expand_act… │ (None, 96, 96,     │           0 │
block2a_expand_b… │
│ (Activation)        │ 96)                │             │
│
├──────────────────────┼────────────────────┼─────────────┼──────────────
─────┤
│ block2a_project_co… │ (None, 96, 96,     │       4,608 │
block2a_expand_a… │
│ (Conv2D)            │ 48)                │             │
│
├──────────────────────┼────────────────────┼─────────────┼──────────────
─────┤
│ block2a_project_bn  │ (None, 96, 96,     │         192 │
block2a_project_… │
│ (BatchNormalizatio… │ 48)                │             │
│
├──────────────────────┼────────────────────┼─────────────┼──────────────
─────┤
│ block2b_expand_conv │ (None, 96, 96,     │      82,944 │
block2a_project_… │
│ (Conv2D)            │ 192)               │             │
│
├──────────────────────┼────────────────────┼─────────────┼──────────────
─────┤
│ block2b_expand_bn   │ (None, 96, 96,     │         768 │
block2b_expand_c… │
│ (BatchNormalizatio… │ 192)               │             │
│
├──────────────────────┼────────────────────┼─────────────┼──────────────
─────┤
│ block2b_expand_act… │ (None, 96, 96,     │           0 │
block2b_expand_b… │
│ (Activation)        │ 192)               │             │
│
├──────────────────────┼────────────────────┼─────────────┼──────────────
─────┤
│ block2b_project_co… │ (None, 96, 96,     │       9,216 │
block2b_expand_a… │
│ (Conv2D)            │ 48)                │             │
│
├──────────────────────┼────────────────────┼─────────────┼──────────────
─────┤
│ block2b_project_bn  │ (None, 96, 96,     │         192 │
block2b_project_… │
│ (BatchNormalizatio… │ 48)                │             │
│
├──────────────────────┼────────────────────┼─────────────┼──────────────
```

```
─────┤
│ block2b_drop        │ (None, 96, 96,     │          0 │
block2b_project_… │
│ (Dropout)           │ 48)                │            │
│
├─────────────────────┼────────────────────┼────────────┼──────────────
─────┤
│ block2b_add (Add)   │ (None, 96, 96,     │          0 │
block2b_drop[0][… │
│                     │ 48)                │            │
block2a_project_… │
├─────────────────────┼────────────────────┼────────────┼──────────────
─────┤
│ block2c_expand_conv │ (None, 96, 96,     │     82,944 │
block2b_add[0][0] │
│ (Conv2D)            │ 192)               │            │
│
├─────────────────────┼────────────────────┼────────────┼──────────────
─────┤
│ block2c_expand_bn   │ (None, 96, 96,     │        768 │
block2c_expand_c… │
│ (BatchNormalizatio… │ 192)               │            │
│
├─────────────────────┼────────────────────┼────────────┼──────────────
─────┤
│ block2c_expand_act… │ (None, 96, 96,     │          0 │
block2c_expand_b… │
│ (Activation)        │ 192)               │            │
│
├─────────────────────┼────────────────────┼────────────┼──────────────
─────┤
│ block2c_project_co… │ (None, 96, 96,     │      9,216 │
block2c_expand_a… │
│ (Conv2D)            │ 48)                │            │
│
├─────────────────────┼────────────────────┼────────────┼──────────────
─────┤
│ block2c_project_bn  │ (None, 96, 96,     │        192 │
block2c_project_… │
│ (BatchNormalizatio… │ 48)                │            │
│
├─────────────────────┼────────────────────┼────────────┼──────────────
─────┤
│ block2c_drop        │ (None, 96, 96,     │          0 │
block2c_project_… │
│ (Dropout)           │ 48)                │            │
│
├─────────────────────┼────────────────────┼────────────┼──────────────
─────┤
```

```
│ block2c_add (Add)   │ (None, 96, 96,     │          0 │
block2c_drop[0][… │
│                     │ 48)                │            │
block2b_add[0][0] │
├─────────────────────┼────────────────────┼────────────┼──────────────
─────┤
│ block2d_expand_conv │ (None, 96, 96,     │     82,944 │
block2c_add[0][0] │
│ (Conv2D)            │ 192)               │            │
│
├─────────────────────┼────────────────────┼────────────┼──────────────
─────┤
│ block2d_expand_bn   │ (None, 96, 96,     │        768 │
block2d_expand_c… │
│ (BatchNormalizatio… │ 192)               │            │
│
├─────────────────────┼────────────────────┼────────────┼──────────────
─────┤
│ block2d_expand_act… │ (None, 96, 96,     │          0 │
block2d_expand_b… │
│ (Activation)        │ 192)               │            │
│
├─────────────────────┼────────────────────┼────────────┼──────────────
─────┤
│ block2d_project_co… │ (None, 96, 96,     │      9,216 │
block2d_expand_a… │
│ (Conv2D)            │ 48)                │            │
│
├─────────────────────┼────────────────────┼────────────┼──────────────
─────┤
│ block2d_project_bn  │ (None, 96, 96,     │        192 │
block2d_project_… │
│ (BatchNormalizatio… │ 48)                │            │
│
├─────────────────────┼────────────────────┼────────────┼──────────────
─────┤
│ block2d_drop        │ (None, 96, 96,     │          0 │
block2d_project_… │
│ (Dropout)           │ 48)                │            │
│
├─────────────────────┼────────────────────┼────────────┼──────────────
─────┤
│ block2d_add (Add)   │ (None, 96, 96,     │          0 │
block2d_drop[0][… │
│                     │ 48)                │            │
block2c_add[0][0] │
├─────────────────────┼────────────────────┼────────────┼──────────────
─────┤
│ block3a_expand_conv │ (None, 48, 48,     │     82,944 │
block2d_add[0][0] │
│ (Conv2D)            │ 192)               │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block3a_expand_bn   │ (None, 48, 48,     │        768 │
block3a_expand_c… │
│ (BatchNormalizatio… │ 192)               │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block3a_expand_act… │ (None, 48, 48,     │          0 │
block3a_expand_b… │
│ (Activation)        │ 192)               │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block3a_project_co… │ (None, 48, 48,     │     12,288 │
block3a_expand_a… │
│ (Conv2D)            │ 64)                │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block3a_project_bn  │ (None, 48, 48,     │        256 │
block3a_project_… │
│ (BatchNormalizatio… │ 64)                │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block3b_expand_conv │ (None, 48, 48,     │    147,456 │
block3a_project_… │
│ (Conv2D)            │ 256)               │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block3b_expand_bn   │ (None, 48, 48,     │      1,024 │
block3b_expand_c… │
│ (BatchNormalizatio… │ 256)               │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block3b_expand_act… │ (None, 48, 48,     │          0 │
block3b_expand_b… │
│ (Activation)        │ 256)               │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block3b_project_co… │ (None, 48, 48,     │     16,384 │
block3b_expand_a… │
```

```
│ (Conv2D)             │ 64)                │             │
│
├──────────────────────┼────────────────────┼─────────────┼──────────────
──────┤
│ block3b_project_bn   │ (None, 48, 48,     │         256 │
block3b_project_… │
│ (BatchNormalizatio…  │ 64)                │             │
│
├──────────────────────┼────────────────────┼─────────────┼──────────────
──────┤
│ block3b_drop         │ (None, 48, 48,     │           0 │
block3b_project_… │
│ (Dropout)            │ 64)                │             │
│
├──────────────────────┼────────────────────┼─────────────┼──────────────
──────┤
│ block3b_add (Add)    │ (None, 48, 48,     │           0 │
block3b_drop[0][… │
│                      │ 64)                │             │
block3a_project_… │
├──────────────────────┼────────────────────┼─────────────┼──────────────
──────┤
│ block3c_expand_conv  │ (None, 48, 48,     │     147,456 │
block3b_add[0][0] │
│ (Conv2D)             │ 256)               │             │
│
├──────────────────────┼────────────────────┼─────────────┼──────────────
──────┤
│ block3c_expand_bn    │ (None, 48, 48,     │       1,024 │
block3c_expand_c… │
│ (BatchNormalizatio…  │ 256)               │             │
│
├──────────────────────┼────────────────────┼─────────────┼──────────────
──────┤
│ block3c_expand_act…  │ (None, 48, 48,     │           0 │
block3c_expand_b… │
│ (Activation)         │ 256)               │             │
│
├──────────────────────┼────────────────────┼─────────────┼──────────────
──────┤
│ block3c_project_co…  │ (None, 48, 48,     │      16,384 │
block3c_expand_a… │
│ (Conv2D)             │ 64)                │             │
│
├──────────────────────┼────────────────────┼─────────────┼──────────────
──────┤
│ block3c_project_bn   │ (None, 48, 48,     │         256 │
block3c_project_… │
│ (BatchNormalizatio…  │ 64)                │             │
```

```
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block3c_drop        │ (None, 48, 48,    │          0 │
block3c_project_… │
│ (Dropout)           │ 64)               │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block3c_add (Add)   │ (None, 48, 48,    │          0 │
block3c_drop[0][… │
│                     │ 64)               │            │
block3b_add[0][0] │
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block3d_expand_conv │ (None, 48, 48,    │    147,456 │
block3c_add[0][0] │
│ (Conv2D)            │ 256)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block3d_expand_bn   │ (None, 48, 48,    │      1,024 │
block3d_expand_c… │
│ (BatchNormalizatio… │ 256)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block3d_expand_act… │ (None, 48, 48,    │          0 │
block3d_expand_b… │
│ (Activation)        │ 256)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block3d_project_co… │ (None, 48, 48,    │     16,384 │
block3d_expand_a… │
│ (Conv2D)            │ 64)               │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block3d_project_bn  │ (None, 48, 48,    │        256 │
block3d_project_… │
│ (BatchNormalizatio… │ 64)               │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block3d_drop        │ (None, 48, 48,    │          0 │
block3d_project_… │
│ (Dropout)           │ 64)               │            │
│
```

```
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block3d_add (Add)   │ (None, 48, 48,    │          0 │
block3d_drop[0][… │
│                     │ 64)               │            │
block3c_add[0][0] │
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block4a_expand_conv │ (None, 48, 48,    │     16,384 │
block3d_add[0][0] │
│ (Conv2D)            │ 256)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block4a_expand_bn   │ (None, 48, 48,    │      1,024 │
block4a_expand_c… │
│ (BatchNormalizatio… │ 256)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block4a_expand_act… │ (None, 48, 48,    │          0 │
block4a_expand_b… │
│ (Activation)        │ 256)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block4a_dwconv2     │ (None, 24, 24,    │      2,304 │
block4a_expand_a… │
│ (DepthwiseConv2D)   │ 256)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block4a_bn          │ (None, 24, 24,    │      1,024 │
block4a_dwconv2[… │
│ (BatchNormalizatio… │ 256)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block4a_activation  │ (None, 24, 24,    │          0 │ block4a_bn[0]
[0]  │
│ (Activation)        │ 256)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block4a_se_squeeze  │ (None, 256)       │          0 │
block4a_activati… │
│ (GlobalAveragePool… │                   │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
```

```
──────┤
│ block4a_se_reshape  │ (None, 1, 1, 256) │          0 │
block4a_se_squee… │
│ (Reshape)           │                   │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
──────┤
│ block4a_se_reduce   │ (None, 1, 1, 16)  │      4,112 │
block4a_se_resha… │
│ (Conv2D)            │                   │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
──────┤
│ block4a_se_expand   │ (None, 1, 1, 256) │      4,352 │
block4a_se_reduc… │
│ (Conv2D)            │                   │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
──────┤
│ block4a_se_excite   │ (None, 24, 24,    │          0 │
block4a_activati… │
│ (Multiply)          │ 256)              │            │
block4a_se_expan… │
├─────────────────────┼───────────────────┼────────────┼──────────────
──────┤
│ block4a_project_co… │ (None, 24, 24,    │     32,768 │
block4a_se_excit… │
│ (Conv2D)            │ 128)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
──────┤
│ block4a_project_bn  │ (None, 24, 24,    │        512 │
block4a_project_… │
│ (BatchNormalizatio… │ 128)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
──────┤
│ block4b_expand_conv │ (None, 24, 24,    │     65,536 │
block4a_project_… │
│ (Conv2D)            │ 512)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
──────┤
│ block4b_expand_bn   │ (None, 24, 24,    │      2,048 │
block4b_expand_c… │
│ (BatchNormalizatio… │ 512)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
──────┤
│ block4b_expand_act… │ (None, 24, 24,    │          0 │
block4b_expand_b… │
│ (Activation)         │ 512)              │             │
│
├──────────────────────┼───────────────────┼─────────────┼──────────────
─────┤
│ block4b_dwconv2      │ (None, 24, 24,    │       4,608 │
block4b_expand_a… │
│ (DepthwiseConv2D)    │ 512)              │             │
│
├──────────────────────┼───────────────────┼─────────────┼──────────────
─────┤
│ block4b_bn           │ (None, 24, 24,    │       2,048 │
block4b_dwconv2[… │
│ (BatchNormalizatio… │ 512)              │             │
│
├──────────────────────┼───────────────────┼─────────────┼──────────────
─────┤
│ block4b_activation   │ (None, 24, 24,    │           0 │ block4b_bn[0]
[0]   │
│ (Activation)         │ 512)              │             │
│
├──────────────────────┼───────────────────┼─────────────┼──────────────
─────┤
│ block4b_se_squeeze   │ (None, 512)       │           0 │
block4b_activati… │
│ (GlobalAveragePool… │                   │             │
│
├──────────────────────┼───────────────────┼─────────────┼──────────────
─────┤
│ block4b_se_reshape   │ (None, 1, 1, 512) │           0 │
block4b_se_squee… │
│ (Reshape)            │                   │             │
│
├──────────────────────┼───────────────────┼─────────────┼──────────────
─────┤
│ block4b_se_reduce    │ (None, 1, 1, 32)  │      16,416 │
block4b_se_resha… │
│ (Conv2D)             │                   │             │
│
├──────────────────────┼───────────────────┼─────────────┼──────────────
─────┤
│ block4b_se_expand    │ (None, 1, 1, 512) │      16,896 │
block4b_se_reduc… │
│ (Conv2D)             │                   │             │
│
├──────────────────────┼───────────────────┼─────────────┼──────────────
─────┤
│ block4b_se_excite    │ (None, 24, 24,    │           0 │
block4b_activati… │
```

```
│ (Multiply)          │ 512)               │             │
block4b_se_expan… │
├─────────────────────┼────────────────────┼─────────────┼──────────────
─────┤
│ block4b_project_co… │ (None, 24, 24,     │      65,536 │
block4b_se_excit… │
│ (Conv2D)            │ 128)               │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
─────┤
│ block4b_project_bn  │ (None, 24, 24,     │         512 │
block4b_project_… │
│ (BatchNormalizatio… │ 128)               │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
─────┤
│ block4b_drop        │ (None, 24, 24,     │           0 │
block4b_project_… │
│ (Dropout)           │ 128)               │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
─────┤
│ block4b_add (Add)   │ (None, 24, 24,     │           0 │
block4b_drop[0][… │
│                     │ 128)               │             │
block4a_project_… │
├─────────────────────┼────────────────────┼─────────────┼──────────────
─────┤
│ block4c_expand_conv │ (None, 24, 24,     │      65,536 │
block4b_add[0][0] │
│ (Conv2D)            │ 512)               │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
─────┤
│ block4c_expand_bn   │ (None, 24, 24,     │       2,048 │
block4c_expand_c… │
│ (BatchNormalizatio… │ 512)               │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
─────┤
│ block4c_expand_act… │ (None, 24, 24,     │           0 │
block4c_expand_b… │
│ (Activation)        │ 512)               │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
─────┤
│ block4c_dwconv2     │ (None, 24, 24,     │       4,608 │
block4c_expand_a… │
│ (DepthwiseConv2D)   │ 512)               │             │
```

```
│
├─────────────────────┼────────────────────┼────────────┼──────────────
──────┤
│ block4c_bn          │ (None, 24, 24,     │      2,048 │
block4c_dwconv2[… │
│ (BatchNormalizatio… │ 512)               │            │
│
├─────────────────────┼────────────────────┼────────────┼──────────────
──────┤
│ block4c_activation  │ (None, 24, 24,     │          0 │ block4c_bn[0]
[0]  │
│ (Activation)        │ 512)               │            │
│
├─────────────────────┼────────────────────┼────────────┼──────────────
──────┤
│ block4c_se_squeeze  │ (None, 512)        │          0 │
block4c_activati… │
│ (GlobalAveragePool… │                    │            │
│
├─────────────────────┼────────────────────┼────────────┼──────────────
──────┤
│ block4c_se_reshape  │ (None, 1, 1, 512)  │          0 │
block4c_se_squee… │
│ (Reshape)           │                    │            │
│
├─────────────────────┼────────────────────┼────────────┼──────────────
──────┤
│ block4c_se_reduce   │ (None, 1, 1, 32)   │     16,416 │
block4c_se_resha… │
│ (Conv2D)            │                    │            │
│
├─────────────────────┼────────────────────┼────────────┼──────────────
──────┤
│ block4c_se_expand   │ (None, 1, 1, 512)  │     16,896 │
block4c_se_reduc… │
│ (Conv2D)            │                    │            │
│
├─────────────────────┼────────────────────┼────────────┼──────────────
──────┤
│ block4c_se_excite   │ (None, 24, 24,     │          0 │
block4c_activati… │
│ (Multiply)          │ 512)               │            │
block4c_se_expan… │
├─────────────────────┼────────────────────┼────────────┼──────────────
──────┤
│ block4c_project_co… │ (None, 24, 24,     │     65,536 │
block4c_se_excit… │
│ (Conv2D)            │ 128)               │            │
│
```

```
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block4c_project_bn  │ (None, 24, 24,    │        512 │
block4c_project_… │
│ (BatchNormalizatio… │ 128)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block4c_drop        │ (None, 24, 24,    │          0 │
block4c_project_… │
│ (Dropout)           │ 128)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block4c_add (Add)   │ (None, 24, 24,    │          0 │
block4c_drop[0][… │
│                     │ 128)              │            │
block4b_add[0][0] │
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block4d_expand_conv │ (None, 24, 24,    │     65,536 │
block4c_add[0][0] │
│ (Conv2D)            │ 512)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block4d_expand_bn   │ (None, 24, 24,    │      2,048 │
block4d_expand_c… │
│ (BatchNormalizatio… │ 512)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block4d_expand_act… │ (None, 24, 24,    │          0 │
block4d_expand_b… │
│ (Activation)        │ 512)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block4d_dwconv2     │ (None, 24, 24,    │      4,608 │
block4d_expand_a… │
│ (DepthwiseConv2D)   │ 512)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block4d_bn          │ (None, 24, 24,    │      2,048 │
block4d_dwconv2[… │
│ (BatchNormalizatio… │ 512)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
```

```
─────┤
│ block4d_activation  │ (None, 24, 24,     │          0 │ block4d_bn[0]
[0]  │
│ (Activation)        │ 512)               │            │
│
├─────────────────────┼────────────────────┼────────────┼───────────────
─────┤
│ block4d_se_squeeze  │ (None, 512)        │          0 │
block4d_activati… │
│ (GlobalAveragePool… │                    │            │
│
├─────────────────────┼────────────────────┼────────────┼───────────────
─────┤
│ block4d_se_reshape  │ (None, 1, 1, 512)  │          0 │
block4d_se_squee… │
│ (Reshape)           │                    │            │
│
├─────────────────────┼────────────────────┼────────────┼───────────────
─────┤
│ block4d_se_reduce   │ (None, 1, 1, 32)   │     16,416 │
block4d_se_resha… │
│ (Conv2D)            │                    │            │
│
├─────────────────────┼────────────────────┼────────────┼───────────────
─────┤
│ block4d_se_expand   │ (None, 1, 1, 512)  │     16,896 │
block4d_se_reduc… │
│ (Conv2D)            │                    │            │
│
├─────────────────────┼────────────────────┼────────────┼───────────────
─────┤
│ block4d_se_excite   │ (None, 24, 24,     │          0 │
block4d_activati… │
│ (Multiply)          │ 512)               │            │
block4d_se_expan… │
├─────────────────────┼────────────────────┼────────────┼───────────────
─────┤
│ block4d_project_co… │ (None, 24, 24,     │     65,536 │
block4d_se_excit… │
│ (Conv2D)            │ 128)               │            │
│
├─────────────────────┼────────────────────┼────────────┼───────────────
─────┤
│ block4d_project_bn  │ (None, 24, 24,     │        512 │
block4d_project_… │
│ (BatchNormalizatio… │ 128)               │            │
│
├─────────────────────┼────────────────────┼────────────┼───────────────
─────┤
```

```
│ block4d_drop        │ (None, 24, 24,    │          0 │
block4d_project_… │
│ (Dropout)           │ 128)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block4d_add (Add)   │ (None, 24, 24,    │          0 │
block4d_drop[0][… │
│                     │ 128)              │            │
block4c_add[0][0] │
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block4e_expand_conv │ (None, 24, 24,    │     65,536 │
block4d_add[0][0] │
│ (Conv2D)            │ 512)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block4e_expand_bn   │ (None, 24, 24,    │      2,048 │
block4e_expand_c… │
│ (BatchNormalizatio… │ 512)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block4e_expand_act… │ (None, 24, 24,    │          0 │
block4e_expand_b… │
│ (Activation)        │ 512)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block4e_dwconv2     │ (None, 24, 24,    │      4,608 │
block4e_expand_a… │
│ (DepthwiseConv2D)   │ 512)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block4e_bn          │ (None, 24, 24,    │      2,048 │
block4e_dwconv2[… │
│ (BatchNormalizatio… │ 512)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block4e_activation  │ (None, 24, 24,    │          0 │ block4e_bn[0]
[0]  │
│ (Activation)        │ 512)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block4e_se_squeeze  │ (None, 512)       │          0 │
```

```
block4e_activati… │
│ (GlobalAveragePool… │                   │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block4e_se_reshape  │ (None, 1, 1, 512) │          0 │
block4e_se_squee… │
│ (Reshape)           │                   │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block4e_se_reduce   │ (None, 1, 1, 32)  │     16,416 │
block4e_se_resha… │
│ (Conv2D)            │                   │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block4e_se_expand   │ (None, 1, 1, 512) │     16,896 │
block4e_se_reduc… │
│ (Conv2D)            │                   │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block4e_se_excite   │ (None, 24, 24,    │          0 │
block4e_activati… │
│ (Multiply)          │ 512)              │            │
block4e_se_expan… │
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block4e_project_co… │ (None, 24, 24,    │     65,536 │
block4e_se_excit… │
│ (Conv2D)            │ 128)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block4e_project_bn  │ (None, 24, 24,    │        512 │
block4e_project_… │
│ (BatchNormalizatio… │ 128)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block4e_drop        │ (None, 24, 24,    │          0 │
block4e_project_… │
│ (Dropout)           │ 128)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block4e_add (Add)   │ (None, 24, 24,    │          0 │
block4e_drop[0][… │
```

```
│                     │ 128)              │            │
block4d_add[0][0] │
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block4f_expand_conv │ (None, 24, 24,    │     65,536 │
block4e_add[0][0] │
│ (Conv2D)            │ 512)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block4f_expand_bn   │ (None, 24, 24,    │      2,048 │
block4f_expand_c… │
│ (BatchNormalizatio… │ 512)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block4f_expand_act… │ (None, 24, 24,    │          0 │
block4f_expand_b… │
│ (Activation)        │ 512)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block4f_dwconv2     │ (None, 24, 24,    │      4,608 │
block4f_expand_a… │
│ (DepthwiseConv2D)   │ 512)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block4f_bn          │ (None, 24, 24,    │      2,048 │
block4f_dwconv2[… │
│ (BatchNormalizatio… │ 512)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block4f_activation  │ (None, 24, 24,    │          0 │ block4f_bn[0]
[0]  │
│ (Activation)        │ 512)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block4f_se_squeeze  │ (None, 512)       │          0 │
block4f_activati… │
│ (GlobalAveragePool… │                   │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block4f_se_reshape  │ (None, 1, 1, 512) │          0 │
block4f_se_squee… │
│ (Reshape)           │                   │            │
```

```
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
─────┤
│ block4f_se_reduce   │ (None, 1, 1, 32)   │      16,416 │
block4f_se_resha… │
│ (Conv2D)            │                    │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
─────┤
│ block4f_se_expand   │ (None, 1, 1, 512)  │      16,896 │
block4f_se_reduc… │
│ (Conv2D)            │                    │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
─────┤
│ block4f_se_excite   │ (None, 24, 24,     │           0 │
block4f_activati… │
│ (Multiply)          │ 512)               │             │
block4f_se_expan… │
├─────────────────────┼────────────────────┼─────────────┼──────────────
─────┤
│ block4f_project_co… │ (None, 24, 24,     │      65,536 │
block4f_se_excit… │
│ (Conv2D)            │ 128)               │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
─────┤
│ block4f_project_bn  │ (None, 24, 24,     │         512 │
block4f_project_… │
│ (BatchNormalizatio… │ 128)               │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
─────┤
│ block4f_drop        │ (None, 24, 24,     │           0 │
block4f_project_… │
│ (Dropout)           │ 128)               │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
─────┤
│ block4f_add (Add)   │ (None, 24, 24,     │           0 │
block4f_drop[0][… │
│                     │ 128)               │             │
block4e_add[0][0] │
├─────────────────────┼────────────────────┼─────────────┼──────────────
─────┤
│ block5a_expand_conv │ (None, 24, 24,     │      98,304 │
block4f_add[0][0] │
│ (Conv2D)            │ 768)               │             │
│
```

```
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block5a_expand_bn   │ (None, 24, 24,    │      3,072 │
block5a_expand_c… │
│ (BatchNormalizatio… │ 768)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block5a_expand_act… │ (None, 24, 24,    │          0 │
block5a_expand_b… │
│ (Activation)        │ 768)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block5a_dwconv2     │ (None, 24, 24,    │      6,912 │
block5a_expand_a… │
│ (DepthwiseConv2D)   │ 768)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block5a_bn          │ (None, 24, 24,    │      3,072 │
block5a_dwconv2[… │
│ (BatchNormalizatio… │ 768)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block5a_activation  │ (None, 24, 24,    │          0 │ block5a_bn[0]
[0]  │
│ (Activation)        │ 768)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block5a_se_squeeze  │ (None, 768)       │          0 │
block5a_activati… │
│ (GlobalAveragePool… │                   │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block5a_se_reshape  │ (None, 1, 1, 768) │          0 │
block5a_se_squee… │
│ (Reshape)           │                   │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block5a_se_reduce   │ (None, 1, 1, 32)  │     24,608 │
block5a_se_resha… │
│ (Conv2D)            │                   │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
```

```
──────┤
│ block5a_se_expand   │ (None, 1, 1, 768) │     25,344 │
block5a_se_reduc… │
│ (Conv2D)            │                   │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
──────┤
│ block5a_se_excite   │ (None, 24, 24,    │          0 │
block5a_activati… │
│ (Multiply)          │ 768)              │            │
block5a_se_expan… │
├─────────────────────┼───────────────────┼────────────┼──────────────
──────┤
│ block5a_project_co… │ (None, 24, 24,    │    122,880 │
block5a_se_excit… │
│ (Conv2D)            │ 160)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
──────┤
│ block5a_project_bn  │ (None, 24, 24,    │        640 │
block5a_project_… │
│ (BatchNormalizatio… │ 160)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
──────┤
│ block5b_expand_conv │ (None, 24, 24,    │    153,600 │
block5a_project_… │
│ (Conv2D)            │ 960)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
──────┤
│ block5b_expand_bn   │ (None, 24, 24,    │      3,840 │
block5b_expand_c… │
│ (BatchNormalizatio… │ 960)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
──────┤
│ block5b_expand_act… │ (None, 24, 24,    │          0 │
block5b_expand_b… │
│ (Activation)        │ 960)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
──────┤
│ block5b_dwconv2     │ (None, 24, 24,    │      8,640 │
block5b_expand_a… │
│ (DepthwiseConv2D)   │ 960)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
──────┤
│ block5b_bn          │ (None, 24, 24,    │      3,840 │
block5b_dwconv2[… │
│ (BatchNormalizatio… │ 960)              │             │
│
├─────────────────────┼───────────────────┼─────────────┼──────────────
─────┤
│ block5b_activation  │ (None, 24, 24,    │           0 │ block5b_bn[0]
[0]  │
│ (Activation)        │ 960)              │             │
│
├─────────────────────┼───────────────────┼─────────────┼──────────────
─────┤
│ block5b_se_squeeze  │ (None, 960)       │           0 │
block5b_activati… │
│ (GlobalAveragePool… │                   │             │
│
├─────────────────────┼───────────────────┼─────────────┼──────────────
─────┤
│ block5b_se_reshape  │ (None, 1, 1, 960) │           0 │
block5b_se_squee… │
│ (Reshape)           │                   │             │
│
├─────────────────────┼───────────────────┼─────────────┼──────────────
─────┤
│ block5b_se_reduce   │ (None, 1, 1, 40)  │      38,440 │
block5b_se_resha… │
│ (Conv2D)            │                   │             │
│
├─────────────────────┼───────────────────┼─────────────┼──────────────
─────┤
│ block5b_se_expand   │ (None, 1, 1, 960) │      39,360 │
block5b_se_reduc… │
│ (Conv2D)            │                   │             │
│
├─────────────────────┼───────────────────┼─────────────┼──────────────
─────┤
│ block5b_se_excite   │ (None, 24, 24,    │           0 │
block5b_activati… │
│ (Multiply)          │ 960)              │             │
block5b_se_expan… │
├─────────────────────┼───────────────────┼─────────────┼──────────────
─────┤
│ block5b_project_co… │ (None, 24, 24,    │     153,600 │
block5b_se_excit… │
│ (Conv2D)            │ 160)              │             │
│
├─────────────────────┼───────────────────┼─────────────┼──────────────
─────┤
│ block5b_project_bn  │ (None, 24, 24,    │         640 │
block5b_project_… │
```

```
│ (BatchNormalizatio… │ 160)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
──────┤
│ block5b_drop        │ (None, 24, 24,    │          0 │
block5b_project_… │
│ (Dropout)           │ 160)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
──────┤
│ block5b_add (Add)   │ (None, 24, 24,    │          0 │
block5b_drop[0][… │
│                     │ 160)              │            │
block5a_project_… │
├─────────────────────┼───────────────────┼────────────┼──────────────
──────┤
│ block5c_expand_conv │ (None, 24, 24,    │    153,600 │
block5b_add[0][0] │
│ (Conv2D)            │ 960)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
──────┤
│ block5c_expand_bn   │ (None, 24, 24,    │      3,840 │
block5c_expand_c… │
│ (BatchNormalizatio… │ 960)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
──────┤
│ block5c_expand_act… │ (None, 24, 24,    │          0 │
block5c_expand_b… │
│ (Activation)        │ 960)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
──────┤
│ block5c_dwconv2     │ (None, 24, 24,    │      8,640 │
block5c_expand_a… │
│ (DepthwiseConv2D)   │ 960)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
──────┤
│ block5c_bn          │ (None, 24, 24,    │      3,840 │
block5c_dwconv2[… │
│ (BatchNormalizatio… │ 960)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
──────┤
│ block5c_activation  │ (None, 24, 24,    │          0 │ block5c_bn[0]
[0]  │
│ (Activation)        │ 960)              │            │
```

```
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block5c_se_squeeze  │ (None, 960)       │          0 │
block5c_activati… │
│ (GlobalAveragePool… │                   │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block5c_se_reshape  │ (None, 1, 1, 960) │          0 │
block5c_se_squee… │
│ (Reshape)           │                   │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block5c_se_reduce   │ (None, 1, 1, 40)  │     38,440 │
block5c_se_resha… │
│ (Conv2D)            │                   │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block5c_se_expand   │ (None, 1, 1, 960) │     39,360 │
block5c_se_reduc… │
│ (Conv2D)            │                   │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block5c_se_excite   │ (None, 24, 24,    │          0 │
block5c_activati… │
│ (Multiply)          │ 960)              │            │
block5c_se_expan… │
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block5c_project_co… │ (None, 24, 24,    │    153,600 │
block5c_se_excit… │
│ (Conv2D)            │ 160)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block5c_project_bn  │ (None, 24, 24,    │        640 │
block5c_project_… │
│ (BatchNormalizatio… │ 160)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block5c_drop        │ (None, 24, 24,    │          0 │
block5c_project_… │
│ (Dropout)           │ 160)              │            │
│
```

```
├─────────────────────┼────────────────────┼──────────────┼──────────────
─────┤
│ block5c_add (Add)   │ (None, 24, 24,     │            0 │
block5c_drop[0][… │
│                     │ 160)               │              │
block5b_add[0][0] │
├─────────────────────┼────────────────────┼──────────────┼──────────────
─────┤
│ block5d_expand_conv │ (None, 24, 24,     │      153,600 │
block5c_add[0][0] │
│ (Conv2D)            │ 960)               │              │
│
├─────────────────────┼────────────────────┼──────────────┼──────────────
─────┤
│ block5d_expand_bn   │ (None, 24, 24,     │        3,840 │
block5d_expand_c… │
│ (BatchNormalizatio… │ 960)               │              │
│
├─────────────────────┼────────────────────┼──────────────┼──────────────
─────┤
│ block5d_expand_act… │ (None, 24, 24,     │            0 │
block5d_expand_b… │
│ (Activation)        │ 960)               │              │
│
├─────────────────────┼────────────────────┼──────────────┼──────────────
─────┤
│ block5d_dwconv2     │ (None, 24, 24,     │        8,640 │
block5d_expand_a… │
│ (DepthwiseConv2D)   │ 960)               │              │
│
├─────────────────────┼────────────────────┼──────────────┼──────────────
─────┤
│ block5d_bn          │ (None, 24, 24,     │        3,840 │
block5d_dwconv2[… │
│ (BatchNormalizatio… │ 960)               │              │
│
├─────────────────────┼────────────────────┼──────────────┼──────────────
─────┤
│ block5d_activation  │ (None, 24, 24,     │            0 │ block5d_bn[0]
[0]  │
│ (Activation)        │ 960)               │              │
│
├─────────────────────┼────────────────────┼──────────────┼──────────────
─────┤
│ block5d_se_squeeze  │ (None, 960)        │            0 │
block5d_activati… │
│ (GlobalAveragePool… │                    │              │
│
├─────────────────────┼────────────────────┼──────────────┼──────────────
```

```
─────┤
│ block5d_se_reshape  │ (None, 1, 1, 960) │          0 │
block5d_se_squee… │
│ (Reshape)           │                   │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block5d_se_reduce   │ (None, 1, 1, 40)  │     38,440 │
block5d_se_resha… │
│ (Conv2D)            │                   │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block5d_se_expand   │ (None, 1, 1, 960) │     39,360 │
block5d_se_reduc… │
│ (Conv2D)            │                   │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block5d_se_excite   │ (None, 24, 24,    │          0 │
block5d_activati… │
│ (Multiply)          │ 960)              │            │
block5d_se_expan… │
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block5d_project_co… │ (None, 24, 24,    │    153,600 │
block5d_se_excit… │
│ (Conv2D)            │ 160)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block5d_project_bn  │ (None, 24, 24,    │        640 │
block5d_project_… │
│ (BatchNormalizatio… │ 160)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block5d_drop        │ (None, 24, 24,    │          0 │
block5d_project_… │
│ (Dropout)           │ 160)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block5d_add (Add)   │ (None, 24, 24,    │          0 │
block5d_drop[0][… │
│                     │ 160)              │            │
block5c_add[0][0] │
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
```

```
│ block5e_expand_conv │ (None, 24, 24,     │     153,600 │
block5d_add[0][0] │
│ (Conv2D)            │ 960)               │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
─────┤
│ block5e_expand_bn   │ (None, 24, 24,     │       3,840 │
block5e_expand_c… │
│ (BatchNormalizatio… │ 960)               │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
─────┤
│ block5e_expand_act… │ (None, 24, 24,     │           0 │
block5e_expand_b… │
│ (Activation)        │ 960)               │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
─────┤
│ block5e_dwconv2     │ (None, 24, 24,     │       8,640 │
block5e_expand_a… │
│ (DepthwiseConv2D)   │ 960)               │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
─────┤
│ block5e_bn          │ (None, 24, 24,     │       3,840 │
block5e_dwconv2[… │
│ (BatchNormalizatio… │ 960)               │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
─────┤
│ block5e_activation  │ (None, 24, 24,     │           0 │ block5e_bn[0]
[0]  │
│ (Activation)        │ 960)               │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
─────┤
│ block5e_se_squeeze  │ (None, 960)        │           0 │
block5e_activati… │
│ (GlobalAveragePool… │                    │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
─────┤
│ block5e_se_reshape  │ (None, 1, 1, 960)  │           0 │
block5e_se_squee… │
│ (Reshape)           │                    │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
─────┤
│ block5e_se_reduce   │ (None, 1, 1, 40)   │      38,440 │
```

```
block5e_se_resha… │
│ (Conv2D)            │                   │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block5e_se_expand   │ (None, 1, 1, 960) │     39,360 │
block5e_se_reduc… │
│ (Conv2D)            │                   │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block5e_se_excite   │ (None, 24, 24,    │          0 │
block5e_activati… │
│ (Multiply)          │ 960)              │            │
block5e_se_expan… │
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block5e_project_co… │ (None, 24, 24,    │    153,600 │
block5e_se_excit… │
│ (Conv2D)            │ 160)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block5e_project_bn  │ (None, 24, 24,    │        640 │
block5e_project_… │
│ (BatchNormalizatio… │ 160)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block5e_drop        │ (None, 24, 24,    │          0 │
block5e_project_… │
│ (Dropout)           │ 160)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block5e_add (Add)   │ (None, 24, 24,    │          0 │
block5e_drop[0][… │
│                     │ 160)              │            │
block5d_add[0][0] │
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block5f_expand_conv │ (None, 24, 24,    │    153,600 │
block5e_add[0][0] │
│ (Conv2D)            │ 960)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block5f_expand_bn   │ (None, 24, 24,    │      3,840 │
block5f_expand_c… │
```

```
│ (BatchNormalizatio… │ 960)               │             │
│
├─────────────────────┼────────────────────┼─────────────┼───────────────
─────┤
│ block5f_expand_act… │ (None, 24, 24,     │           0 │
block5f_expand_b… │
│ (Activation)        │ 960)               │             │
│
├─────────────────────┼────────────────────┼─────────────┼───────────────
─────┤
│ block5f_dwconv2     │ (None, 24, 24,     │       8,640 │
block5f_expand_a… │
│ (DepthwiseConv2D)   │ 960)               │             │
│
├─────────────────────┼────────────────────┼─────────────┼───────────────
─────┤
│ block5f_bn          │ (None, 24, 24,     │       3,840 │
block5f_dwconv2[… │
│ (BatchNormalizatio… │ 960)               │             │
│
├─────────────────────┼────────────────────┼─────────────┼───────────────
─────┤
│ block5f_activation  │ (None, 24, 24,     │           0 │ block5f_bn[0]
[0]  │
│ (Activation)        │ 960)               │             │
│
├─────────────────────┼────────────────────┼─────────────┼───────────────
─────┤
│ block5f_se_squeeze  │ (None, 960)        │           0 │
block5f_activati… │
│ (GlobalAveragePool… │                    │             │
│
├─────────────────────┼────────────────────┼─────────────┼───────────────
─────┤
│ block5f_se_reshape  │ (None, 1, 1, 960)  │           0 │
block5f_se_squee… │
│ (Reshape)           │                    │             │
│
├─────────────────────┼────────────────────┼─────────────┼───────────────
─────┤
│ block5f_se_reduce   │ (None, 1, 1, 40)   │      38,440 │
block5f_se_resha… │
│ (Conv2D)            │                    │             │
│
├─────────────────────┼────────────────────┼─────────────┼───────────────
─────┤
│ block5f_se_expand   │ (None, 1, 1, 960)  │      39,360 │
block5f_se_reduc… │
│ (Conv2D)            │                    │             │
```

```
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block5f_se_excite   │ (None, 24, 24,    │          0 │
block5f_activati… │
│ (Multiply)          │ 960)              │            │
block5f_se_expan… │
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block5f_project_co… │ (None, 24, 24,    │    153,600 │
block5f_se_excit… │
│ (Conv2D)            │ 160)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block5f_project_bn  │ (None, 24, 24,    │        640 │
block5f_project_… │
│ (BatchNormalizatio… │ 160)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block5f_drop        │ (None, 24, 24,    │          0 │
block5f_project_… │
│ (Dropout)           │ 160)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block5f_add (Add)   │ (None, 24, 24,    │          0 │
block5f_drop[0][… │
│                     │ 160)              │            │
block5e_add[0][0] │
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block5g_expand_conv │ (None, 24, 24,    │    153,600 │
block5f_add[0][0] │
│ (Conv2D)            │ 960)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block5g_expand_bn   │ (None, 24, 24,    │      3,840 │
block5g_expand_c… │
│ (BatchNormalizatio… │ 960)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block5g_expand_act… │ (None, 24, 24,    │          0 │
block5g_expand_b… │
│ (Activation)        │ 960)              │            │
│
```

```
├─────────────────────┼────────────────────┼────────────┼─────────────
──────┤
│ block5g_dwconv2     │ (None, 24, 24,     │      8,640 │
block5g_expand_a… │
│ (DepthwiseConv2D)   │ 960)               │            │
│
├─────────────────────┼────────────────────┼────────────┼─────────────
──────┤
│ block5g_bn          │ (None, 24, 24,     │      3,840 │
block5g_dwconv2[… │
│ (BatchNormalizatio… │ 960)               │            │
│
├─────────────────────┼────────────────────┼────────────┼─────────────
──────┤
│ block5g_activation  │ (None, 24, 24,     │          0 │ block5g_bn[0]
[0]  │
│ (Activation)        │ 960)               │            │
│
├─────────────────────┼────────────────────┼────────────┼─────────────
──────┤
│ block5g_se_squeeze  │ (None, 960)        │          0 │
block5g_activati… │
│ (GlobalAveragePool… │                    │            │
│
├─────────────────────┼────────────────────┼────────────┼─────────────
──────┤
│ block5g_se_reshape  │ (None, 1, 1, 960)  │          0 │
block5g_se_squee… │
│ (Reshape)           │                    │            │
│
├─────────────────────┼────────────────────┼────────────┼─────────────
──────┤
│ block5g_se_reduce   │ (None, 1, 1, 40)   │     38,440 │
block5g_se_resha… │
│ (Conv2D)            │                    │            │
│
├─────────────────────┼────────────────────┼────────────┼─────────────
──────┤
│ block5g_se_expand   │ (None, 1, 1, 960)  │     39,360 │
block5g_se_reduc… │
│ (Conv2D)            │                    │            │
│
├─────────────────────┼────────────────────┼────────────┼─────────────
──────┤
│ block5g_se_excite   │ (None, 24, 24,     │          0 │
block5g_activati… │
│ (Multiply)          │ 960)               │            │
block5g_se_expan… │
├─────────────────────┼────────────────────┼────────────┼─────────────
```

```
──────┤
│ block5g_project_co… │ (None, 24, 24,      │     153,600 │
block5g_se_excit… │
│ (Conv2D)            │ 160)                │             │
│
├─────────────────────┼─────────────────────┼─────────────┼──────────────
──────┤
│ block5g_project_bn  │ (None, 24, 24,      │         640 │
block5g_project_… │
│ (BatchNormalizatio… │ 160)                │             │
│
├─────────────────────┼─────────────────────┼─────────────┼──────────────
──────┤
│ block5g_drop        │ (None, 24, 24,      │           0 │
block5g_project_… │
│ (Dropout)           │ 160)                │             │
│
├─────────────────────┼─────────────────────┼─────────────┼──────────────
──────┤
│ block5g_add (Add)   │ (None, 24, 24,      │           0 │
block5g_drop[0][… │
│                     │ 160)                │             │
block5f_add[0][0] │
├─────────────────────┼─────────────────────┼─────────────┼──────────────
──────┤
│ block5h_expand_conv │ (None, 24, 24,      │     153,600 │
block5g_add[0][0] │
│ (Conv2D)            │ 960)                │             │
│
├─────────────────────┼─────────────────────┼─────────────┼──────────────
──────┤
│ block5h_expand_bn   │ (None, 24, 24,      │       3,840 │
block5h_expand_c… │
│ (BatchNormalizatio… │ 960)                │             │
│
├─────────────────────┼─────────────────────┼─────────────┼──────────────
──────┤
│ block5h_expand_act… │ (None, 24, 24,      │           0 │
block5h_expand_b… │
│ (Activation)        │ 960)                │             │
│
├─────────────────────┼─────────────────────┼─────────────┼──────────────
──────┤
│ block5h_dwconv2     │ (None, 24, 24,      │       8,640 │
block5h_expand_a… │
│ (DepthwiseConv2D)   │ 960)                │             │
│
├─────────────────────┼─────────────────────┼─────────────┼──────────────
──────┤
│ block5h_bn          │ (None, 24, 24,      │       3,840 │
block5h_dwconv2[… │
│ (BatchNormalizatio… │ 960)              │             │
│
├─────────────────────┼───────────────────┼─────────────┼──────────────
──────┤
│ block5h_activation  │ (None, 24, 24,    │           0 │ block5h_bn[0]
[0]  │
│ (Activation)        │ 960)              │             │
│
├─────────────────────┼───────────────────┼─────────────┼──────────────
──────┤
│ block5h_se_squeeze  │ (None, 960)       │           0 │
block5h_activati… │
│ (GlobalAveragePool… │                   │             │
│
├─────────────────────┼───────────────────┼─────────────┼──────────────
──────┤
│ block5h_se_reshape  │ (None, 1, 1, 960) │           0 │
block5h_se_squee… │
│ (Reshape)           │                   │             │
│
├─────────────────────┼───────────────────┼─────────────┼──────────────
──────┤
│ block5h_se_reduce   │ (None, 1, 1, 40)  │      38,440 │
block5h_se_resha… │
│ (Conv2D)            │                   │             │
│
├─────────────────────┼───────────────────┼─────────────┼──────────────
──────┤
│ block5h_se_expand   │ (None, 1, 1, 960) │      39,360 │
block5h_se_reduc… │
│ (Conv2D)            │                   │             │
│
├─────────────────────┼───────────────────┼─────────────┼──────────────
──────┤
│ block5h_se_excite   │ (None, 24, 24,    │           0 │
block5h_activati… │
│ (Multiply)          │ 960)              │             │
block5h_se_expan… │
├─────────────────────┼───────────────────┼─────────────┼──────────────
──────┤
│ block5h_project_co… │ (None, 24, 24,    │     153,600 │
block5h_se_excit… │
│ (Conv2D)            │ 160)              │             │
│
├─────────────────────┼───────────────────┼─────────────┼──────────────
──────┤
│ block5h_project_bn  │ (None, 24, 24,    │         640 │
block5h_project_… │
```

```
│ (BatchNormalizatio… │ 160)                │                │
│
├─────────────────────┼─────────────────────┼────────────────┼────────────────
───────┤
│ block5h_drop        │ (None, 24, 24,      │              0 │
block5h_project_… │
│ (Dropout)           │ 160)                │                │
│
├─────────────────────┼─────────────────────┼────────────────┼────────────────
───────┤
│ block5h_add (Add)   │ (None, 24, 24,      │              0 │
block5h_drop[0][… │
│                     │ 160)                │                │
block5g_add[0][0] │
├─────────────────────┼─────────────────────┼────────────────┼────────────────
───────┤
│ block5i_expand_conv │ (None, 24, 24,      │        153,600 │
block5h_add[0][0] │
│ (Conv2D)            │ 960)                │                │
│
├─────────────────────┼─────────────────────┼────────────────┼────────────────
───────┤
│ block5i_expand_bn   │ (None, 24, 24,      │          3,840 │
block5i_expand_c… │
│ (BatchNormalizatio… │ 960)                │                │
│
├─────────────────────┼─────────────────────┼────────────────┼────────────────
───────┤
│ block5i_expand_act… │ (None, 24, 24,      │              0 │
block5i_expand_b… │
│ (Activation)        │ 960)                │                │
│
├─────────────────────┼─────────────────────┼────────────────┼────────────────
───────┤
│ block5i_dwconv2     │ (None, 24, 24,      │          8,640 │
block5i_expand_a… │
│ (DepthwiseConv2D)   │ 960)                │                │
│
├─────────────────────┼─────────────────────┼────────────────┼────────────────
───────┤
│ block5i_bn          │ (None, 24, 24,      │          3,840 │
block5i_dwconv2[… │
│ (BatchNormalizatio… │ 960)                │                │
│
├─────────────────────┼─────────────────────┼────────────────┼────────────────
───────┤
│ block5i_activation  │ (None, 24, 24,      │              0 │ block5i_bn[0]
[0]  │
│ (Activation)        │ 960)                │                │
```

```
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block5i_se_squeeze  │ (None, 960)       │          0 │
block5i_activati… │
│ (GlobalAveragePool… │                   │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block5i_se_reshape  │ (None, 1, 1, 960) │          0 │
block5i_se_squee… │
│ (Reshape)           │                   │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block5i_se_reduce   │ (None, 1, 1, 40)  │     38,440 │
block5i_se_resha… │
│ (Conv2D)            │                   │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block5i_se_expand   │ (None, 1, 1, 960) │     39,360 │
block5i_se_reduc… │
│ (Conv2D)            │                   │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block5i_se_excite   │ (None, 24, 24,    │          0 │
block5i_activati… │
│ (Multiply)          │ 960)              │            │
block5i_se_expan… │
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block5i_project_co… │ (None, 24, 24,    │    153,600 │
block5i_se_excit… │
│ (Conv2D)            │ 160)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block5i_project_bn  │ (None, 24, 24,    │        640 │
block5i_project_… │
│ (BatchNormalizatio… │ 160)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block5i_drop        │ (None, 24, 24,    │          0 │
block5i_project_… │
│ (Dropout)           │ 160)              │            │
│
```

```
├─────────────────────┼───────────────────┼────────────┼──────────────
──────┤
│ block5i_add (Add)   │ (None, 24, 24,    │          0 │
block5i_drop[0][… │
│                     │ 160)              │            │
block5h_add[0][0] │
├─────────────────────┼───────────────────┼────────────┼──────────────
──────┤
│ block6a_expand_conv │ (None, 24, 24,    │    153,600 │
block5i_add[0][0] │
│ (Conv2D)            │ 960)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
──────┤
│ block6a_expand_bn   │ (None, 24, 24,    │      3,840 │
block6a_expand_c… │
│ (BatchNormalizatio… │ 960)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
──────┤
│ block6a_expand_act… │ (None, 24, 24,    │          0 │
block6a_expand_b… │
│ (Activation)        │ 960)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
──────┤
│ block6a_dwconv2     │ (None, 12, 12,    │      8,640 │
block6a_expand_a… │
│ (DepthwiseConv2D)   │ 960)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
──────┤
│ block6a_bn          │ (None, 12, 12,    │      3,840 │
block6a_dwconv2[… │
│ (BatchNormalizatio… │ 960)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
──────┤
│ block6a_activation  │ (None, 12, 12,    │          0 │ block6a_bn[0]
[0]  │
│ (Activation)        │ 960)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
──────┤
│ block6a_se_squeeze  │ (None, 960)       │          0 │
block6a_activati… │
│ (GlobalAveragePool… │                   │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
```

```
───────┤
│ block6a_se_reshape  │ (None, 1, 1, 960) │          0 │
block6a_se_squee… │
│ (Reshape)           │                   │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
───────┤
│ block6a_se_reduce   │ (None, 1, 1, 40)  │     38,440 │
block6a_se_resha… │
│ (Conv2D)            │                   │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
───────┤
│ block6a_se_expand   │ (None, 1, 1, 960) │     39,360 │
block6a_se_reduc… │
│ (Conv2D)            │                   │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
───────┤
│ block6a_se_excite   │ (None, 12, 12,    │          0 │
block6a_activati… │
│ (Multiply)          │ 960)              │            │
block6a_se_expan… │
├─────────────────────┼───────────────────┼────────────┼──────────────
───────┤
│ block6a_project_co… │ (None, 12, 12,    │    245,760 │
block6a_se_excit… │
│ (Conv2D)            │ 256)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
───────┤
│ block6a_project_bn  │ (None, 12, 12,    │      1,024 │
block6a_project_… │
│ (BatchNormalizatio… │ 256)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
───────┤
│ block6b_expand_conv │ (None, 12, 12,    │    393,216 │
block6a_project_… │
│ (Conv2D)            │ 1536)             │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
───────┤
│ block6b_expand_bn   │ (None, 12, 12,    │      6,144 │
block6b_expand_c… │
│ (BatchNormalizatio… │ 1536)             │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
───────┤
```

```
│ block6b_expand_act… │ (None, 12, 12,      │          0 │
block6b_expand_b… │
│ (Activation)        │ 1536)               │            │
│
├─────────────────────┼─────────────────────┼────────────┼───────────────
─────┤
│ block6b_dwconv2     │ (None, 12, 12,      │     13,824 │
block6b_expand_a… │
│ (DepthwiseConv2D)   │ 1536)               │            │
│
├─────────────────────┼─────────────────────┼────────────┼───────────────
─────┤
│ block6b_bn          │ (None, 12, 12,      │      6,144 │
block6b_dwconv2[… │
│ (BatchNormalizatio… │ 1536)               │            │
│
├─────────────────────┼─────────────────────┼────────────┼───────────────
─────┤
│ block6b_activation  │ (None, 12, 12,      │          0 │ block6b_bn[0]
[0]  │
│ (Activation)        │ 1536)               │            │
│
├─────────────────────┼─────────────────────┼────────────┼───────────────
─────┤
│ block6b_se_squeeze  │ (None, 1536)        │          0 │
block6b_activati… │
│ (GlobalAveragePool… │                     │            │
│
├─────────────────────┼─────────────────────┼────────────┼───────────────
─────┤
│ block6b_se_reshape  │ (None, 1, 1,        │          0 │
block6b_se_squee… │
│ (Reshape)           │ 1536)               │            │
│
├─────────────────────┼─────────────────────┼────────────┼───────────────
─────┤
│ block6b_se_reduce   │ (None, 1, 1, 64)    │     98,368 │
block6b_se_resha… │
│ (Conv2D)            │                     │            │
│
├─────────────────────┼─────────────────────┼────────────┼───────────────
─────┤
│ block6b_se_expand   │ (None, 1, 1,        │     99,840 │
block6b_se_reduc… │
│ (Conv2D)            │ 1536)               │            │
│
├─────────────────────┼─────────────────────┼────────────┼───────────────
─────┤
│ block6b_se_excite   │ (None, 12, 12,      │          0 │
block6b_activati… │
│ (Multiply)          │ 1536)               │             │
block6b_se_expan… │
├─────────────────────┼─────────────────────┼─────────────┼───────────────
─────┤
│ block6b_project_co… │ (None, 12, 12,      │     393,216 │
block6b_se_excit… │
│ (Conv2D)            │ 256)                │             │
│
├─────────────────────┼─────────────────────┼─────────────┼───────────────
─────┤
│ block6b_project_bn  │ (None, 12, 12,      │       1,024 │
block6b_project_… │
│ (BatchNormalizatio… │ 256)                │             │
│
├─────────────────────┼─────────────────────┼─────────────┼───────────────
─────┤
│ block6b_drop        │ (None, 12, 12,      │           0 │
block6b_project_… │
│ (Dropout)           │ 256)                │             │
│
├─────────────────────┼─────────────────────┼─────────────┼───────────────
─────┤
│ block6b_add (Add)   │ (None, 12, 12,      │           0 │
block6b_drop[0][… │
│                     │ 256)                │             │
block6a_project_… │
├─────────────────────┼─────────────────────┼─────────────┼───────────────
─────┤
│ block6c_expand_conv │ (None, 12, 12,      │     393,216 │
block6b_add[0][0] │
│ (Conv2D)            │ 1536)               │             │
│
├─────────────────────┼─────────────────────┼─────────────┼───────────────
─────┤
│ block6c_expand_bn   │ (None, 12, 12,      │       6,144 │
block6c_expand_c… │
│ (BatchNormalizatio… │ 1536)               │             │
│
├─────────────────────┼─────────────────────┼─────────────┼───────────────
─────┤
│ block6c_expand_act… │ (None, 12, 12,      │           0 │
block6c_expand_b… │
│ (Activation)        │ 1536)               │             │
│
├─────────────────────┼─────────────────────┼─────────────┼───────────────
─────┤
│ block6c_dwconv2     │ (None, 12, 12,      │      13,824 │
block6c_expand_a… │
```

```
│ (DepthwiseConv2D)   │ 1536)             │             │
│
├─────────────────────┼───────────────────┼─────────────┼──────────────
─────┤
│ block6c_bn          │ (None, 12, 12,    │       6,144 │
block6c_dwconv2[… │
│ (BatchNormalizatio… │ 1536)             │             │
│
├─────────────────────┼───────────────────┼─────────────┼──────────────
─────┤
│ block6c_activation  │ (None, 12, 12,    │           0 │ block6c_bn[0]
[0]  │
│ (Activation)        │ 1536)             │             │
│
├─────────────────────┼───────────────────┼─────────────┼──────────────
─────┤
│ block6c_se_squeeze  │ (None, 1536)      │           0 │
block6c_activati… │
│ (GlobalAveragePool… │                   │             │
│
├─────────────────────┼───────────────────┼─────────────┼──────────────
─────┤
│ block6c_se_reshape  │ (None, 1, 1,      │           0 │
block6c_se_squee… │
│ (Reshape)           │ 1536)             │             │
│
├─────────────────────┼───────────────────┼─────────────┼──────────────
─────┤
│ block6c_se_reduce   │ (None, 1, 1, 64)  │      98,368 │
block6c_se_resha… │
│ (Conv2D)            │                   │             │
│
├─────────────────────┼───────────────────┼─────────────┼──────────────
─────┤
│ block6c_se_expand   │ (None, 1, 1,      │      99,840 │
block6c_se_reduc… │
│ (Conv2D)            │ 1536)             │             │
│
├─────────────────────┼───────────────────┼─────────────┼──────────────
─────┤
│ block6c_se_excite   │ (None, 12, 12,    │           0 │
block6c_activati… │
│ (Multiply)          │ 1536)             │             │
block6c_se_expan… │
├─────────────────────┼───────────────────┼─────────────┼──────────────
─────┤
│ block6c_project_co… │ (None, 12, 12,    │     393,216 │
block6c_se_excit… │
│ (Conv2D)            │ 256)              │             │
```

```
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
─────┤
│ block6c_project_bn  │ (None, 12, 12,     │       1,024 │
block6c_project_… │
│ (BatchNormalizatio… │ 256)               │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
─────┤
│ block6c_drop        │ (None, 12, 12,     │           0 │
block6c_project_… │
│ (Dropout)           │ 256)               │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
─────┤
│ block6c_add (Add)   │ (None, 12, 12,     │           0 │
block6c_drop[0][… │
│                     │ 256)               │             │
block6b_add[0][0] │
├─────────────────────┼────────────────────┼─────────────┼──────────────
─────┤
│ block6d_expand_conv │ (None, 12, 12,     │     393,216 │
block6c_add[0][0] │
│ (Conv2D)            │ 1536)              │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
─────┤
│ block6d_expand_bn   │ (None, 12, 12,     │       6,144 │
block6d_expand_c… │
│ (BatchNormalizatio… │ 1536)              │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
─────┤
│ block6d_expand_act… │ (None, 12, 12,     │           0 │
block6d_expand_b… │
│ (Activation)        │ 1536)              │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
─────┤
│ block6d_dwconv2     │ (None, 12, 12,     │      13,824 │
block6d_expand_a… │
│ (DepthwiseConv2D)   │ 1536)              │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
─────┤
│ block6d_bn          │ (None, 12, 12,     │       6,144 │
block6d_dwconv2[… │
│ (BatchNormalizatio… │ 1536)              │             │
│
```

```
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6d_activation  │ (None, 12, 12,    │          0 │ block6d_bn[0]
[0]  │
│ (Activation)        │ 1536)             │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6d_se_squeeze  │ (None, 1536)      │          0 │
block6d_activati… │
│ (GlobalAveragePool… │                   │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6d_se_reshape  │ (None, 1, 1,      │          0 │
block6d_se_squee… │
│ (Reshape)           │ 1536)             │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6d_se_reduce   │ (None, 1, 1, 64)  │     98,368 │
block6d_se_resha… │
│ (Conv2D)            │                   │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6d_se_expand   │ (None, 1, 1,      │     99,840 │
block6d_se_reduc… │
│ (Conv2D)            │ 1536)             │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6d_se_excite   │ (None, 12, 12,    │          0 │
block6d_activati… │
│ (Multiply)          │ 1536)             │            │
block6d_se_expan… │
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6d_project_co… │ (None, 12, 12,    │    393,216 │
block6d_se_excit… │
│ (Conv2D)            │ 256)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6d_project_bn  │ (None, 12, 12,    │      1,024 │
block6d_project_… │
│ (BatchNormalizatio… │ 256)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
```

```
─────┤
│ block6d_drop         │ (None, 12, 12,     │           0 │
block6d_project_… │
│ (Dropout)            │ 256)               │             │
│
├──────────────────────┼────────────────────┼─────────────┼──────────────
─────┤
│ block6d_add (Add)    │ (None, 12, 12,     │           0 │
block6d_drop[0][… │
│                      │ 256)               │             │
block6c_add[0][0] │
├──────────────────────┼────────────────────┼─────────────┼──────────────
─────┤
│ block6e_expand_conv  │ (None, 12, 12,     │     393,216 │
block6d_add[0][0] │
│ (Conv2D)             │ 1536)              │             │
│
├──────────────────────┼────────────────────┼─────────────┼──────────────
─────┤
│ block6e_expand_bn    │ (None, 12, 12,     │       6,144 │
block6e_expand_c… │
│ (BatchNormalizatio…  │ 1536)              │             │
│
├──────────────────────┼────────────────────┼─────────────┼──────────────
─────┤
│ block6e_expand_act…  │ (None, 12, 12,     │           0 │
block6e_expand_b… │
│ (Activation)         │ 1536)              │             │
│
├──────────────────────┼────────────────────┼─────────────┼──────────────
─────┤
│ block6e_dwconv2      │ (None, 12, 12,     │      13,824 │
block6e_expand_a… │
│ (DepthwiseConv2D)    │ 1536)              │             │
│
├──────────────────────┼────────────────────┼─────────────┼──────────────
─────┤
│ block6e_bn           │ (None, 12, 12,     │       6,144 │
block6e_dwconv2[… │
│ (BatchNormalizatio…  │ 1536)              │             │
│
├──────────────────────┼────────────────────┼─────────────┼──────────────
─────┤
│ block6e_activation   │ (None, 12, 12,     │           0 │ block6e_bn[0]
[0]  │
│ (Activation)         │ 1536)              │             │
│
├──────────────────────┼────────────────────┼─────────────┼──────────────
─────┤
│ block6e_se_squeeze   │ (None, 1536)       │           0 │
```

```
block6e_activati… │
│ (GlobalAveragePool… │                   │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6e_se_reshape  │ (None, 1, 1,      │          0 │
block6e_se_squee… │
│ (Reshape)           │ 1536)             │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6e_se_reduce   │ (None, 1, 1, 64)  │     98,368 │
block6e_se_resha… │
│ (Conv2D)            │                   │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6e_se_expand   │ (None, 1, 1,      │     99,840 │
block6e_se_reduc… │
│ (Conv2D)            │ 1536)             │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6e_se_excite   │ (None, 12, 12,    │          0 │
block6e_activati… │
│ (Multiply)          │ 1536)             │            │
block6e_se_expan… │
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6e_project_co… │ (None, 12, 12,    │    393,216 │
block6e_se_excit… │
│ (Conv2D)            │ 256)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6e_project_bn  │ (None, 12, 12,    │      1,024 │
block6e_project_… │
│ (BatchNormalizatio… │ 256)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6e_drop        │ (None, 12, 12,    │          0 │
block6e_project_… │
│ (Dropout)           │ 256)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6e_add (Add)   │ (None, 12, 12,    │          0 │
block6e_drop[0][… │
```

```
│                     │ 256)               │             │
block6d_add[0][0] │
├─────────────────────┼────────────────────┼─────────────┼──────────────
──────┤
│ block6f_expand_conv │ (None, 12, 12,     │     393,216 │
block6e_add[0][0] │
│ (Conv2D)            │ 1536)              │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
──────┤
│ block6f_expand_bn   │ (None, 12, 12,     │       6,144 │
block6f_expand_c… │
│ (BatchNormalizatio… │ 1536)              │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
──────┤
│ block6f_expand_act… │ (None, 12, 12,     │           0 │
block6f_expand_b… │
│ (Activation)        │ 1536)              │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
──────┤
│ block6f_dwconv2     │ (None, 12, 12,     │      13,824 │
block6f_expand_a… │
│ (DepthwiseConv2D)   │ 1536)              │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
──────┤
│ block6f_bn          │ (None, 12, 12,     │       6,144 │
block6f_dwconv2[… │
│ (BatchNormalizatio… │ 1536)              │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
──────┤
│ block6f_activation  │ (None, 12, 12,     │           0 │ block6f_bn[0]
[0]  │
│ (Activation)        │ 1536)              │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
──────┤
│ block6f_se_squeeze  │ (None, 1536)       │           0 │
block6f_activati… │
│ (GlobalAveragePool… │                    │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
──────┤
│ block6f_se_reshape  │ (None, 1, 1,       │           0 │
block6f_se_squee… │
│ (Reshape)           │ 1536)              │             │
```

```
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6f_se_reduce   │ (None, 1, 1, 64)  │     98,368 │
block6f_se_resha… │
│ (Conv2D)            │                   │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6f_se_expand   │ (None, 1, 1,      │     99,840 │
block6f_se_reduc… │
│ (Conv2D)            │ 1536)             │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6f_se_excite   │ (None, 12, 12,    │          0 │
block6f_activati… │
│ (Multiply)          │ 1536)             │            │
block6f_se_expan… │
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6f_project_co… │ (None, 12, 12,    │    393,216 │
block6f_se_excit… │
│ (Conv2D)            │ 256)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6f_project_bn  │ (None, 12, 12,    │      1,024 │
block6f_project_… │
│ (BatchNormalizatio… │ 256)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6f_drop        │ (None, 12, 12,    │          0 │
block6f_project_… │
│ (Dropout)           │ 256)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6f_add (Add)   │ (None, 12, 12,    │          0 │
block6f_drop[0][… │
│                     │ 256)              │            │
block6e_add[0][0] │
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6g_expand_conv │ (None, 12, 12,    │    393,216 │
block6f_add[0][0] │
│ (Conv2D)            │ 1536)             │            │
│
```

```
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6g_expand_bn   │ (None, 12, 12,    │      6,144 │
block6g_expand_c… │
│ (BatchNormalizatio… │ 1536)             │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6g_expand_act… │ (None, 12, 12,    │          0 │
block6g_expand_b… │
│ (Activation)        │ 1536)             │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6g_dwconv2     │ (None, 12, 12,    │     13,824 │
block6g_expand_a… │
│ (DepthwiseConv2D)   │ 1536)             │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6g_bn          │ (None, 12, 12,    │      6,144 │
block6g_dwconv2[… │
│ (BatchNormalizatio… │ 1536)             │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6g_activation  │ (None, 12, 12,    │          0 │ block6g_bn[0]
[0]  │
│ (Activation)        │ 1536)             │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6g_se_squeeze  │ (None, 1536)      │          0 │
block6g_activati… │
│ (GlobalAveragePool… │                   │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6g_se_reshape  │ (None, 1, 1,      │          0 │
block6g_se_squee… │
│ (Reshape)           │ 1536)             │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6g_se_reduce   │ (None, 1, 1, 64)  │     98,368 │
block6g_se_resha… │
│ (Conv2D)            │                   │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
```

```
─────┤
│ block6g_se_expand   │ (None, 1, 1,      │     99,840 │
block6g_se_reduc… │
│ (Conv2D)            │ 1536)             │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6g_se_excite   │ (None, 12, 12,    │          0 │
block6g_activati… │
│ (Multiply)          │ 1536)             │            │
block6g_se_expan… │
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6g_project_co… │ (None, 12, 12,    │    393,216 │
block6g_se_excit… │
│ (Conv2D)            │ 256)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6g_project_bn  │ (None, 12, 12,    │      1,024 │
block6g_project_… │
│ (BatchNormalizatio… │ 256)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6g_drop        │ (None, 12, 12,    │          0 │
block6g_project_… │
│ (Dropout)           │ 256)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6g_add (Add)   │ (None, 12, 12,    │          0 │
block6g_drop[0][… │
│                     │ 256)              │            │
block6f_add[0][0] │
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6h_expand_conv │ (None, 12, 12,    │    393,216 │
block6g_add[0][0] │
│ (Conv2D)            │ 1536)             │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6h_expand_bn   │ (None, 12, 12,    │      6,144 │
block6h_expand_c… │
│ (BatchNormalizatio… │ 1536)             │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
```

```
│ block6h_expand_act… │ (None, 12, 12,    │          0 │
block6h_expand_b… │
│ (Activation)        │ 1536)             │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6h_dwconv2     │ (None, 12, 12,    │     13,824 │
block6h_expand_a… │
│ (DepthwiseConv2D)   │ 1536)             │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6h_bn          │ (None, 12, 12,    │      6,144 │
block6h_dwconv2[… │
│ (BatchNormalizatio… │ 1536)             │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6h_activation  │ (None, 12, 12,    │          0 │ block6h_bn[0]
[0]  │
│ (Activation)        │ 1536)             │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6h_se_squeeze  │ (None, 1536)      │          0 │
block6h_activati… │
│ (GlobalAveragePool… │                   │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6h_se_reshape  │ (None, 1, 1,      │          0 │
block6h_se_squee… │
│ (Reshape)           │ 1536)             │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6h_se_reduce   │ (None, 1, 1, 64)  │     98,368 │
block6h_se_resha… │
│ (Conv2D)            │                   │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6h_se_expand   │ (None, 1, 1,      │     99,840 │
block6h_se_reduc… │
│ (Conv2D)            │ 1536)             │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6h_se_excite   │ (None, 12, 12,    │          0 │
block6h_activati… │
│ (Multiply)          │ 1536)             │            │
block6h_se_expan… │
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6h_project_co… │ (None, 12, 12,    │    393,216 │
block6h_se_excit… │
│ (Conv2D)            │ 256)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6h_project_bn  │ (None, 12, 12,    │      1,024 │
block6h_project_… │
│ (BatchNormalizatio… │ 256)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6h_drop        │ (None, 12, 12,    │          0 │
block6h_project_… │
│ (Dropout)           │ 256)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6h_add (Add)   │ (None, 12, 12,    │          0 │
block6h_drop[0][… │
│                     │ 256)              │            │
block6g_add[0][0] │
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6i_expand_conv │ (None, 12, 12,    │    393,216 │
block6h_add[0][0] │
│ (Conv2D)            │ 1536)             │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6i_expand_bn   │ (None, 12, 12,    │      6,144 │
block6i_expand_c… │
│ (BatchNormalizatio… │ 1536)             │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6i_expand_act… │ (None, 12, 12,    │          0 │
block6i_expand_b… │
│ (Activation)        │ 1536)             │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6i_dwconv2     │ (None, 12, 12,    │     13,824 │
block6i_expand_a… │
```

```
│ (DepthwiseConv2D)   │ 1536)             │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6i_bn          │ (None, 12, 12,    │      6,144 │
block6i_dwconv2[… │
│ (BatchNormalizatio… │ 1536)             │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6i_activation  │ (None, 12, 12,    │          0 │ block6i_bn[0]
[0]  │
│ (Activation)        │ 1536)             │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6i_se_squeeze  │ (None, 1536)      │          0 │
block6i_activati… │
│ (GlobalAveragePool… │                   │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6i_se_reshape  │ (None, 1, 1,      │          0 │
block6i_se_squee… │
│ (Reshape)           │ 1536)             │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6i_se_reduce   │ (None, 1, 1, 64)  │     98,368 │
block6i_se_resha… │
│ (Conv2D)            │                   │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6i_se_expand   │ (None, 1, 1,      │     99,840 │
block6i_se_reduc… │
│ (Conv2D)            │ 1536)             │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6i_se_excite   │ (None, 12, 12,    │          0 │
block6i_activati… │
│ (Multiply)          │ 1536)             │            │
block6i_se_expan… │
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6i_project_co… │ (None, 12, 12,    │    393,216 │
block6i_se_excit… │
│ (Conv2D)            │ 256)              │            │
```

```
│
├─────────────────────┼────────────────────┼────────────┼──────────────
─────┤
│ block6i_project_bn  │ (None, 12, 12,     │      1,024 │
block6i_project_… │
│ (BatchNormalizatio… │ 256)               │            │
│
├─────────────────────┼────────────────────┼────────────┼──────────────
─────┤
│ block6i_drop        │ (None, 12, 12,     │          0 │
block6i_project_… │
│ (Dropout)           │ 256)               │            │
│
├─────────────────────┼────────────────────┼────────────┼──────────────
─────┤
│ block6i_add (Add)   │ (None, 12, 12,     │          0 │
block6i_drop[0][… │
│                     │ 256)               │            │
block6h_add[0][0] │
├─────────────────────┼────────────────────┼────────────┼──────────────
─────┤
│ block6j_expand_conv │ (None, 12, 12,     │    393,216 │
block6i_add[0][0] │
│ (Conv2D)            │ 1536)              │            │
│
├─────────────────────┼────────────────────┼────────────┼──────────────
─────┤
│ block6j_expand_bn   │ (None, 12, 12,     │      6,144 │
block6j_expand_c… │
│ (BatchNormalizatio… │ 1536)              │            │
│
├─────────────────────┼────────────────────┼────────────┼──────────────
─────┤
│ block6j_expand_act… │ (None, 12, 12,     │          0 │
block6j_expand_b… │
│ (Activation)        │ 1536)              │            │
│
├─────────────────────┼────────────────────┼────────────┼──────────────
─────┤
│ block6j_dwconv2     │ (None, 12, 12,     │     13,824 │
block6j_expand_a… │
│ (DepthwiseConv2D)   │ 1536)              │            │
│
├─────────────────────┼────────────────────┼────────────┼──────────────
─────┤
│ block6j_bn          │ (None, 12, 12,     │      6,144 │
block6j_dwconv2[… │
│ (BatchNormalizatio… │ 1536)              │            │
│
```

```
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6j_activation  │ (None, 12, 12,    │          0 │ block6j_bn[0]
[0]  │
│ (Activation)        │ 1536)             │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6j_se_squeeze  │ (None, 1536)      │          0 │
block6j_activati… │
│ (GlobalAveragePool… │                   │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6j_se_reshape  │ (None, 1, 1,      │          0 │
block6j_se_squee… │
│ (Reshape)           │ 1536)             │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6j_se_reduce   │ (None, 1, 1, 64)  │     98,368 │
block6j_se_resha… │
│ (Conv2D)            │                   │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6j_se_expand   │ (None, 1, 1,      │     99,840 │
block6j_se_reduc… │
│ (Conv2D)            │ 1536)             │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6j_se_excite   │ (None, 12, 12,    │          0 │
block6j_activati… │
│ (Multiply)          │ 1536)             │            │
block6j_se_expan… │
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6j_project_co… │ (None, 12, 12,    │    393,216 │
block6j_se_excit… │
│ (Conv2D)            │ 256)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6j_project_bn  │ (None, 12, 12,    │      1,024 │
block6j_project_… │
│ (BatchNormalizatio… │ 256)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
```

```
──────┤
│ block6j_drop        │ (None, 12, 12,     │           0 │
block6j_project_… │
│ (Dropout)           │ 256)               │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
──────┤
│ block6j_add (Add)   │ (None, 12, 12,     │           0 │
block6j_drop[0][… │
│                     │ 256)               │             │
block6i_add[0][0] │
├─────────────────────┼────────────────────┼─────────────┼──────────────
──────┤
│ block6k_expand_conv │ (None, 12, 12,     │     393,216 │
block6j_add[0][0] │
│ (Conv2D)            │ 1536)              │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
──────┤
│ block6k_expand_bn   │ (None, 12, 12,     │       6,144 │
block6k_expand_c… │
│ (BatchNormalizatio… │ 1536)              │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
──────┤
│ block6k_expand_act… │ (None, 12, 12,     │           0 │
block6k_expand_b… │
│ (Activation)        │ 1536)              │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
──────┤
│ block6k_dwconv2     │ (None, 12, 12,     │      13,824 │
block6k_expand_a… │
│ (DepthwiseConv2D)   │ 1536)              │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
──────┤
│ block6k_bn          │ (None, 12, 12,     │       6,144 │
block6k_dwconv2[… │
│ (BatchNormalizatio… │ 1536)              │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
──────┤
│ block6k_activation  │ (None, 12, 12,     │           0 │ block6k_bn[0]
[0]  │
│ (Activation)        │ 1536)              │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
──────┤
│ block6k_se_squeeze  │ (None, 1536)       │           0 │
```

```
block6k_activati… │
│ (GlobalAveragePool… │                    │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
──────┤
│ block6k_se_reshape  │ (None, 1, 1,       │           0 │
block6k_se_squee… │
│ (Reshape)           │ 1536)              │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
──────┤
│ block6k_se_reduce   │ (None, 1, 1, 64)   │      98,368 │
block6k_se_resha… │
│ (Conv2D)            │                    │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
──────┤
│ block6k_se_expand   │ (None, 1, 1,       │      99,840 │
block6k_se_reduc… │
│ (Conv2D)            │ 1536)              │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
──────┤
│ block6k_se_excite   │ (None, 12, 12,     │           0 │
block6k_activati… │
│ (Multiply)          │ 1536)              │             │
block6k_se_expan… │
├─────────────────────┼────────────────────┼─────────────┼──────────────
──────┤
│ block6k_project_co… │ (None, 12, 12,     │     393,216 │
block6k_se_excit… │
│ (Conv2D)            │ 256)               │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
──────┤
│ block6k_project_bn  │ (None, 12, 12,     │       1,024 │
block6k_project_… │
│ (BatchNormalizatio… │ 256)               │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
──────┤
│ block6k_drop        │ (None, 12, 12,     │           0 │
block6k_project_… │
│ (Dropout)           │ 256)               │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
──────┤
│ block6k_add (Add)   │ (None, 12, 12,     │           0 │
block6k_drop[0][… │
```

```
│                     │ 256)              │            │ 
block6j_add[0][0] │
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6l_expand_conv │ (None, 12, 12,    │    393,216 │ 
block6k_add[0][0] │
│ (Conv2D)            │ 1536)             │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6l_expand_bn   │ (None, 12, 12,    │      6,144 │ 
block6l_expand_c… │
│ (BatchNormalizatio… │ 1536)             │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6l_expand_act… │ (None, 12, 12,    │          0 │ 
block6l_expand_b… │
│ (Activation)        │ 1536)             │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6l_dwconv2     │ (None, 12, 12,    │     13,824 │ 
block6l_expand_a… │
│ (DepthwiseConv2D)   │ 1536)             │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6l_bn          │ (None, 12, 12,    │      6,144 │ 
block6l_dwconv2[… │
│ (BatchNormalizatio… │ 1536)             │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6l_activation  │ (None, 12, 12,    │          0 │ block6l_bn[0]
[0]  │
│ (Activation)        │ 1536)             │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6l_se_squeeze  │ (None, 1536)      │          0 │ 
block6l_activati… │
│ (GlobalAveragePool… │                   │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6l_se_reshape  │ (None, 1, 1,      │          0 │ 
block6l_se_squee… │
│ (Reshape)           │ 1536)             │            │
```

```
│
├─────────────────────┼───────────────────┼────────────┼──────────────
──────┤
│ block6l_se_reduce   │ (None, 1, 1, 64)  │     98,368 │
block6l_se_resha… │
│ (Conv2D)            │                   │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
──────┤
│ block6l_se_expand   │ (None, 1, 1,      │     99,840 │
block6l_se_reduc… │
│ (Conv2D)            │ 1536)             │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
──────┤
│ block6l_se_excite   │ (None, 12, 12,    │          0 │
block6l_activati… │
│ (Multiply)          │ 1536)             │            │
block6l_se_expan… │
├─────────────────────┼───────────────────┼────────────┼──────────────
──────┤
│ block6l_project_co… │ (None, 12, 12,    │    393,216 │
block6l_se_excit… │
│ (Conv2D)            │ 256)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
──────┤
│ block6l_project_bn  │ (None, 12, 12,    │      1,024 │
block6l_project_… │
│ (BatchNormalizatio… │ 256)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
──────┤
│ block6l_drop        │ (None, 12, 12,    │          0 │
block6l_project_… │
│ (Dropout)           │ 256)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
──────┤
│ block6l_add (Add)   │ (None, 12, 12,    │          0 │
block6l_drop[0][… │
│                     │ 256)              │            │
block6k_add[0][0] │
├─────────────────────┼───────────────────┼────────────┼──────────────
──────┤
│ block6m_expand_conv │ (None, 12, 12,    │    393,216 │
block6l_add[0][0] │
│ (Conv2D)            │ 1536)             │            │
│
```

```
├─────────────────────┼────────────────────┼─────────────┼──────────────
──────┤
│ block6m_expand_bn   │ (None, 12, 12,     │       6,144 │
block6m_expand_c… │
│ (BatchNormalizatio… │ 1536)              │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
──────┤
│ block6m_expand_act… │ (None, 12, 12,     │           0 │
block6m_expand_b… │
│ (Activation)        │ 1536)              │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
──────┤
│ block6m_dwconv2     │ (None, 12, 12,     │      13,824 │
block6m_expand_a… │
│ (DepthwiseConv2D)   │ 1536)              │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
──────┤
│ block6m_bn          │ (None, 12, 12,     │       6,144 │
block6m_dwconv2[… │
│ (BatchNormalizatio… │ 1536)              │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
──────┤
│ block6m_activation  │ (None, 12, 12,     │           0 │ block6m_bn[0]
[0]  │
│ (Activation)        │ 1536)              │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
──────┤
│ block6m_se_squeeze  │ (None, 1536)       │           0 │
block6m_activati… │
│ (GlobalAveragePool… │                    │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
──────┤
│ block6m_se_reshape  │ (None, 1, 1,       │           0 │
block6m_se_squee… │
│ (Reshape)           │ 1536)              │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
──────┤
│ block6m_se_reduce   │ (None, 1, 1, 64)   │      98,368 │
block6m_se_resha… │
│ (Conv2D)            │                    │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
```

```
─────┤
│ block6m_se_expand   │ (None, 1, 1,      │     99,840 │
block6m_se_reduc… │
│ (Conv2D)            │ 1536)             │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6m_se_excite   │ (None, 12, 12,    │          0 │
block6m_activati… │
│ (Multiply)          │ 1536)             │            │
block6m_se_expan… │
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6m_project_co… │ (None, 12, 12,    │    393,216 │
block6m_se_excit… │
│ (Conv2D)            │ 256)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6m_project_bn  │ (None, 12, 12,    │      1,024 │
block6m_project_… │
│ (BatchNormalizatio… │ 256)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6m_drop        │ (None, 12, 12,    │          0 │
block6m_project_… │
│ (Dropout)           │ 256)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6m_add (Add)   │ (None, 12, 12,    │          0 │
block6m_drop[0][… │
│                     │ 256)              │            │
block6l_add[0][0] │
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6n_expand_conv │ (None, 12, 12,    │    393,216 │
block6m_add[0][0] │
│ (Conv2D)            │ 1536)             │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6n_expand_bn   │ (None, 12, 12,    │      6,144 │
block6n_expand_c… │
│ (BatchNormalizatio… │ 1536)             │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
```

```
│ block6n_expand_act… │ (None, 12, 12,     │          0 │
block6n_expand_b… │
│ (Activation)        │ 1536)              │            │
│
├─────────────────────┼────────────────────┼────────────┼──────────────
─────┤
│ block6n_dwconv2     │ (None, 12, 12,     │     13,824 │
block6n_expand_a… │
│ (DepthwiseConv2D)   │ 1536)              │            │
│
├─────────────────────┼────────────────────┼────────────┼──────────────
─────┤
│ block6n_bn          │ (None, 12, 12,     │      6,144 │
block6n_dwconv2[… │
│ (BatchNormalizatio… │ 1536)              │            │
│
├─────────────────────┼────────────────────┼────────────┼──────────────
─────┤
│ block6n_activation  │ (None, 12, 12,     │          0 │ block6n_bn[0]
[0]  │
│ (Activation)        │ 1536)              │            │
│
├─────────────────────┼────────────────────┼────────────┼──────────────
─────┤
│ block6n_se_squeeze  │ (None, 1536)       │          0 │
block6n_activati… │
│ (GlobalAveragePool… │                    │            │
│
├─────────────────────┼────────────────────┼────────────┼──────────────
─────┤
│ block6n_se_reshape  │ (None, 1, 1,       │          0 │
block6n_se_squee… │
│ (Reshape)           │ 1536)              │            │
│
├─────────────────────┼────────────────────┼────────────┼──────────────
─────┤
│ block6n_se_reduce   │ (None, 1, 1, 64)   │     98,368 │
block6n_se_resha… │
│ (Conv2D)            │                    │            │
│
├─────────────────────┼────────────────────┼────────────┼──────────────
─────┤
│ block6n_se_expand   │ (None, 1, 1,       │     99,840 │
block6n_se_reduc… │
│ (Conv2D)            │ 1536)              │            │
│
├─────────────────────┼────────────────────┼────────────┼──────────────
─────┤
│ block6n_se_excite   │ (None, 12, 12,     │          0 │
block6n_activati… │
│ (Multiply)          │ 1536)             │            │
block6n_se_expan… │
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6n_project_co… │ (None, 12, 12,    │    393,216 │
block6n_se_excit… │
│ (Conv2D)            │ 256)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6n_project_bn  │ (None, 12, 12,    │      1,024 │
block6n_project_… │
│ (BatchNormalizatio… │ 256)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6n_drop        │ (None, 12, 12,    │          0 │
block6n_project_… │
│ (Dropout)           │ 256)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6n_add (Add)   │ (None, 12, 12,    │          0 │
block6n_drop[0][… │
│                     │ 256)              │            │
block6m_add[0][0] │
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6o_expand_conv │ (None, 12, 12,    │    393,216 │
block6n_add[0][0] │
│ (Conv2D)            │ 1536)             │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6o_expand_bn   │ (None, 12, 12,    │      6,144 │
block6o_expand_c… │
│ (BatchNormalizatio… │ 1536)             │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6o_expand_act… │ (None, 12, 12,    │          0 │
block6o_expand_b… │
│ (Activation)        │ 1536)             │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────
─────┤
│ block6o_dwconv2     │ (None, 12, 12,    │     13,824 │
block6o_expand_a… │
```

```
│ (DepthwiseConv2D)   │ 1536)             │             │
│
├─────────────────────┼───────────────────┼─────────────┼──────────────
─────┤
│ block6o_bn          │ (None, 12, 12,    │       6,144 │
block6o_dwconv2[… │
│ (BatchNormalizatio… │ 1536)             │             │
│
├─────────────────────┼───────────────────┼─────────────┼──────────────
─────┤
│ block6o_activation  │ (None, 12, 12,    │           0 │ block6o_bn[0]
[0]  │
│ (Activation)        │ 1536)             │             │
│
├─────────────────────┼───────────────────┼─────────────┼──────────────
─────┤
│ block6o_se_squeeze  │ (None, 1536)      │           0 │
block6o_activati… │
│ (GlobalAveragePool… │                   │             │
│
├─────────────────────┼───────────────────┼─────────────┼──────────────
─────┤
│ block6o_se_reshape  │ (None, 1, 1,      │           0 │
block6o_se_squee… │
│ (Reshape)           │ 1536)             │             │
│
├─────────────────────┼───────────────────┼─────────────┼──────────────
─────┤
│ block6o_se_reduce   │ (None, 1, 1, 64)  │      98,368 │
block6o_se_resha… │
│ (Conv2D)            │                   │             │
│
├─────────────────────┼───────────────────┼─────────────┼──────────────
─────┤
│ block6o_se_expand   │ (None, 1, 1,      │      99,840 │
block6o_se_reduc… │
│ (Conv2D)            │ 1536)             │             │
│
├─────────────────────┼───────────────────┼─────────────┼──────────────
─────┤
│ block6o_se_excite   │ (None, 12, 12,    │           0 │
block6o_activati… │
│ (Multiply)          │ 1536)             │             │
block6o_se_expan… │
├─────────────────────┼───────────────────┼─────────────┼──────────────
─────┤
│ block6o_project_co… │ (None, 12, 12,    │     393,216 │
block6o_se_excit… │
│ (Conv2D)            │ 256)              │             │
```

```
│
├─────────────────────┼───────────────────┼────────────┼───────────────
──────┤
│ block6o_project_bn  │ (None, 12, 12,    │      1,024 │
block6o_project_… │
│ (BatchNormalizatio… │ 256)              │            │
│
├─────────────────────┼───────────────────┼────────────┼───────────────
──────┤
│ block6o_drop        │ (None, 12, 12,    │          0 │
block6o_project_… │
│ (Dropout)           │ 256)              │            │
│
├─────────────────────┼───────────────────┼────────────┼───────────────
──────┤
│ block6o_add (Add)   │ (None, 12, 12,    │          0 │
block6o_drop[0][… │
│                     │ 256)              │            │
block6n_add[0][0] │
├─────────────────────┼───────────────────┼────────────┼───────────────
──────┤
│ top_conv (Conv2D)   │ (None, 12, 12,    │    327,680 │
block6o_add[0][0] │
│                     │ 1280)             │            │
│
├─────────────────────┼───────────────────┼────────────┼───────────────
──────┤
│ top_bn              │ (None, 12, 12,    │      5,120 │ top_conv[0]
[0]    │
│ (BatchNormalizatio… │ 1280)             │            │
│
├─────────────────────┼───────────────────┼────────────┼───────────────
──────┤
│ top_activation      │ (None, 12, 12,    │          0 │ top_bn[0][0]
│
│ (Activation)        │ 1280)             │            │
│
├─────────────────────┼───────────────────┼────────────┼───────────────
──────┤
│ avg_pool            │ (None, 1280)      │          0 │
top_activation[0… │
│ (GlobalAveragePool… │                   │            │
│
├─────────────────────┼───────────────────┼────────────┼───────────────
──────┤
│ dropout (Dropout)   │ (None, 1280)      │          0 │ avg_pool[0]
[0]    │
├─────────────────────┼───────────────────┼────────────┼───────────────
──────┤
```

```
│ dense (Dense)         │ (None, 512)        │     655,872 │ dropout[0][0]
│
├───────────────────────┼────────────────────┼─────────────┼──────────────
─────┤
│ batch_normalization   │ (None, 512)        │       2,048 │ dense[0][0]
│
│ (BatchNormalizatio…   │                    │             │
│
├───────────────────────┼────────────────────┼─────────────┼──────────────
─────┤
│ dropout_1 (Dropout)   │ (None, 512)        │           0 │
batch_normalizat… │
├───────────────────────┼────────────────────┼─────────────┼──────────────
─────┤
│ dense_1 (Dense)       │ (None, 5)          │       2,565 │ dropout_1[0]
[0]    │
└───────────────────────┴────────────────────┴─────────────┴──────────────
─────┘

 Total params: 20,991,845 (80.08 MB)

 Trainable params: 20,836,949 (79.49 MB)

 Non-trainable params: 154,896 (605.06 KB)
```

```
# compile
try:
    opt = AdamW(learning_rate=1e-3, weight_decay=1e-5)
except:
    opt = tf.keras.optimizers.Adam(learning_rate=1e-3)

img_model.compile(optimizer=opt, loss='categorical_crossentropy',
metrics=['accuracy'])

# callbacks
ckpdir = WORK / "img_model_ckpt"
ckpdir.mkdir(parents=True, exist_ok=True)
checkpoint =
tf.keras.callbacks.ModelCheckpoint(str(ckpdir/"best_img_model.h5"),
monitor='val_accuracy', save_best_only=True)
reduce_lr =
tf.keras.callbacks.ReduceLROnPlateau(monitor='val_accuracy',
factor=0.5, patience=2, min_lr=1e-6)
es = tf.keras.callbacks.EarlyStopping(monitor='val_accuracy',
patience=4, restore_best_weights=True)

# ----------------------------
# Correct Freezing
# ----------------------------
# Freeze ONLY the EfficientNetV2 backbone
for layer in img_model.layers:
    if isinstance(layer, tf.keras.Model):   # this is your backbone
        layer.trainable = False

# Confirm trainable layers > 0
print("\nTrainable layers:", len([l for l in img_model.layers if
l.trainable]))
```

```
Trainable layers: 519
```

```
# ----------------------------
# Train head (backbone frozen)
# ----------------------------
with tf.device('/GPU:0'):
    img_model.fit(
        train_ds,
        validation_data=val_ds,
        epochs=6,
        callbacks=[checkpoint, reduce_lr, es],
        verbose=1
    )
```

```
Epoch 1/6
```

```
Training:   0%|          | 0/6 [10:08<?, ?epoch/s]
```

```
 109/1334 ━━━━━━━━━━━━━━━━━━━━ 11:10 547ms/step - accuracy: 0.4604 -
loss: 1.80537, change: 0.00048548
Epoch 688, change: 0.00048467
Epoch 689, change: 0.00057171
Epoch 690, change: 0.00054990
Epoch 691, change: 0.00049963
Epoch 692, change: 0.00047757
Epoch 693, change: 0.00047706
Epoch 694, change: 0.00048026
Epoch 695, change: 0.00049388
Epoch 696, change: 0.00047755
Epoch 697, change: 0.00050943
Epoch 698, change: 0.00061429
Epoch 699, change: 0.00059540
Epoch 700, change: 0.00058166
Epoch 701, change: 0.00055285
Epoch 702, change: 0.00059817
Epoch 703, change: 0.00058357
Epoch 704, change: 0.00053986
Epoch 705, change: 0.00056116
Epoch 706, change: 0.00068714
Epoch 707, change: 0.00058157
Epoch 708, change: 0.00054707
Epoch 709, change: 0.00057102
Epoch 710, change: 0.00062779
Epoch 711, change: 0.00059379
Epoch 712, change: 0.00053080
Epoch 713, change: 0.00047713
Epoch 714, change: 0.00047919
Epoch 715, change: 0.00067189
Epoch 716, change: 0.00047746
Epoch 717, change: 0.00066196
Epoch 718, change: 0.00047751
Epoch 719, change: 0.00051658
Epoch 720, change: 0.00051816
Epoch 721, change: 0.00052806
Epoch 722, change: 0.00047719
Epoch 723, change: 0.00055022
Epoch 724, change: 0.00054325
Epoch 725, change: 0.00048434
Epoch 726, change: 0.00051453
Epoch 727, change: 0.00078443
Epoch 728, change: 0.00047761
Epoch 729, change: 0.00047701
Epoch 730, change: 0.00063485
Epoch 731, change: 0.00052403
Epoch 732, change: 0.00050580
Epoch 733, change: 0.00055541
Epoch 734, change: 0.00047727
Epoch 735, change: 0.00047713
Epoch 736, change: 0.00051104
Epoch 737, change: 0.00061378
Epoch 738, change: 0.00048026
Epoch 739, change: 0.00054427
Epoch 740, change: 0.00047800
Epoch 741, change: 0.00047721
Epoch 742, change: 0.00047697
Epoch 743, change: 0.00052770
Epoch 744, change: 0.00049206
Epoch 745, change: 0.00047721
Epoch 746, change: 0.00047703
Epoch 747, change: 0.00048151
Epoch 748, change: 0.00055195
Epoch 749, change: 0.00050893
Epoch 750, change: 0.00058580
Epoch 751, change: 0.00047724
Epoch 752, change: 0.00060350
Epoch 753, change: 0.00049480
Epoch 754, change: 0.00047724
Epoch 755, change: 0.00047728
Epoch 756, change: 0.00047707
Epoch 757, change: 0.00047746
Epoch 758, change: 0.00047681
Epoch 759, change: 0.00047716
Epoch 760, change: 0.00047701
Epoch 761, change: 0.00047710
Epoch 762, change: 0.00047704
Epoch 763, change: 0.00047739
Epoch 764, change: 0.00047712
Epoch 765, change: 0.00047743
Epoch 766, change: 0.00047703
Epoch 767, change: 0.00047713
Epoch 768, change: 0.00047721
Epoch 769, change: 0.00047733
Epoch 770, change: 0.00047727
Epoch 771, change: 0.00047707
Epoch 772, change: 0.00047682
Epoch 773, change: 0.00047737
Epoch 774, change: 0.00047707
Epoch 775, change: 0.00047707
Epoch 776, change: 0.00055147
Epoch 777, change: 0.00047679
Epoch 778, change: 0.00047721
Epoch 779, change: 0.00047701
Epoch 780, change: 0.00047700
Epoch 781, change: 0.00047716
Epoch 782, change: 0.00047683
Epoch 783, change: 0.00047709
Epoch 784, change: 0.00047709
Epoch 785, change: 0.00047692
Epoch 786, change: 0.00047704
Epoch 787, change: 0.00047727
Epoch 788, change: 0.00055141
Epoch 789, change: 0.00047743
Epoch 790, change: 0.00047706
Epoch 791, change: 0.00060350
Epoch 792, change: 0.00057036
Epoch 793, change: 0.00047713
Epoch 794, change: 0.00050785
Epoch 795, change: 0.00047707
Epoch 796, change: 0.00047704
Epoch 797, change: 0.00047659
Epoch 798, change: 0.00052779
Epoch 799, change: 0.00047700
Epoch 800, change: 0.00057647
Epoch 801, change: 0.00047704
Epoch 802, change: 0.00047691
Epoch 803, change: 0.00047735
Epoch 804, change: 0.00047695
Epoch 805, change: 0.00053765
Epoch 806, change: 0.00047689
Epoch 807, change: 0.00055183
Epoch 808, change: 0.00048565
Epoch 809, change: 0.00052031
Epoch 810, change: 0.00050687
Epoch 811, change: 0.00049653
Epoch 812, change: 0.00047645
Epoch 813, change: 0.00055177
Epoch 814, change: 0.00047874
Epoch 815, change: 0.00053622
Epoch 816, change: 0.00048592
Epoch 817, change: 0.00055171
Epoch 818, change: 0.00047661
Epoch 819, change: 0.00055651
Epoch 820, change: 0.00047710
Epoch 821, change: 0.00055100
Epoch 822, change: 0.00063049
 581/1334 ━━━━━━━━━━━━━━━━━━━━ 7:27 594ms/step - accuracy: 0.5722 -
loss: 1.265155153
Epoch 824, change: 0.00047703
Epoch 825, change: 0.00054289
Epoch 826, change: 0.00047664
Epoch 827, change: 0.00060683
Epoch 828, change: 0.00047704
Epoch 829, change: 0.00052603
Epoch 830, change: 0.00048729
Epoch 831, change: 0.00056208
Epoch 832, change: 0.00047649
Epoch 833, change: 0.00057561
Epoch 834, change: 0.00049316
Epoch 835, change: 0.00055183
Epoch 836, change: 0.00054435
Epoch 837, change: 0.00051563
Epoch 838, change: 0.00047647
Epoch 839, change: 0.00047698
Epoch 840, change: 0.00047689
Epoch 841, change: 0.00047841
Epoch 842, change: 0.00061810
Epoch 843, change: 0.00047658
Epoch 844, change: 0.00063836
Epoch 845, change: 0.00047656
Epoch 846, change: 0.00055183
Epoch 847, change: 0.00047659
Epoch 848, change: 0.00047637
Epoch 849, change: 0.00047603
Epoch 850, change: 0.00050836
Epoch 851, change: 0.00047621
Epoch 852, change: 0.00057984
Epoch 853, change: 0.00047637
Epoch 854, change: 0.00047613
Epoch 855, change: 0.00047622
Epoch 856, change: 0.00048050
Epoch 857, change: 0.00047656
Epoch 858, change: 0.00059286
Epoch 859, change: 0.00047577
Epoch 860, change: 0.00055165
Epoch 861, change: 0.00047638
Epoch 862, change: 0.00061291
Epoch 863, change: 0.00047634
Epoch 864, change: 0.00055254
Epoch 865, change: 0.00047658
Epoch 866, change: 0.00053461
Epoch 867, change: 0.00047634
Epoch 868, change: 0.00055195
Epoch 869, change: 0.00047693
Epoch 870, change: 0.00047598
Epoch 871, change: 0.00047589
Epoch 872, change: 0.00055171
Epoch 873, change: 0.00047643
Epoch 874, change: 0.00055153
Epoch 875, change: 0.00047622
Epoch 876, change: 0.00055165
Epoch 877, change: 0.00047613
Epoch 878, change: 0.00050493
Epoch 879, change: 0.00047606
Epoch 880, change: 0.00049790
Epoch 881, change: 0.00047617
Epoch 882, change: 0.00047655
Epoch 883, change: 0.00048234
Epoch 884, change: 0.00052888
Epoch 885, change: 0.00047652
Epoch 886, change: 0.00047604
Epoch 887, change: 0.00047664
Epoch 888, change: 0.00047607
Epoch 889, change: 0.00047643
Epoch 890, change: 0.00047640
Epoch 891, change: 0.00047664
Epoch 892, change: 0.00047623
Epoch 893, change: 0.00055853
Epoch 894, change: 0.00047667
Epoch 895, change: 0.00047635
Epoch 896, change: 0.00047617
Epoch 897, change: 0.00047643
Epoch 898, change: 0.00047617
Epoch 899, change: 0.00051792
Epoch 900, change: 0.00047637
Epoch 901, change: 0.00047623
Epoch 902, change: 0.00051643
Epoch 903, change: 0.00047653
Epoch 904, change: 0.00047605
Epoch 905, change: 0.00047602
Epoch 906, change: 0.00047619
Epoch 907, change: 0.00047619
Epoch 908, change: 0.00047625
Epoch 909, change: 0.00047638
Epoch 910, change: 0.00047649
Epoch 911, change: 0.00047629
Epoch 912, change: 0.00047629
Epoch 913, change: 0.00048890
Epoch 914, change: 0.00047634
Epoch 915, change: 0.00047647
Epoch 916, change: 0.00041931
Epoch 917, change: 0.00038923
Epoch 918, change: 0.00036483
Epoch 919, change: 0.00037579
Epoch 920, change: 0.00042038
Epoch 921, change: 0.00028455
Epoch 922, change: 0.00047094
Epoch 923, change: 0.00036418
Epoch 924, change: 0.00040436
Epoch 925, change: 0.00032560
Epoch 926, change: 0.00038333
Epoch 927, change: 0.00042580
Epoch 928, change: 0.00042540
Epoch 929, change: 0.00040130
Epoch 930, change: 0.00042391
Epoch 931, change: 0.00030672
Epoch 932, change: 0.00034045
Epoch 933, change: 0.00051056
Epoch 934, change: 0.00037811
Epoch 935, change: 0.00028294
Epoch 936, change: 0.00042848
Epoch 937, change: 0.00035022
Epoch 938, change: 0.00041533
Epoch 939, change: 0.00039021
Epoch 940, change: 0.00035666
Epoch 941, change: 0.00045624
Epoch 942, change: 0.00038880
Epoch 943, change: 0.00029099
Epoch 944, change: 0.00030830
Epoch 945, change: 0.00050266
Epoch 946, change: 0.00044320
Epoch 947, change: 0.00032965
Epoch 948, change: 0.00028329
Epoch 949, change: 0.00030636
Epoch 950, change: 0.00037229
Epoch 951, change: 0.00030276
Epoch 952, change: 0.00044505
Epoch 953, change: 0.00046545
Epoch 954, change: 0.00032476
Epoch 955, change: 0.00028065
Epoch 956, change: 0.00042623
Epoch 957, change: 0.00041554
Epoch 958, change: 0.00040946
Epoch 959, change: 0.00033974
 722/1334 ━━━━━━━━━━━━━━━━━━━━ 6:05 598ms/step - accuracy: 0.5839 -
loss: 1.2136max_iter reached after 1734 seconds
 723/1334 ━━━━━━━━━━━━━━━━━━━━ 6:05 598ms/step - accuracy: 0.5840 -
loss: 1.2132

/usr/local/lib/python3.11/dist-packages/sklearn/linear_model/
_sag.py:350: ConvergenceWarning: The max_iter was reached which means
the coef_ did not converge
  warnings.warn(

1334/1334 ━━━━━━━━━━━━━━━━━━━━ 0s 604ms/step - accuracy: 0.6167 -
loss: 1.0776

WARNING:absl:You are saving your model as an HDF5 file via
`model.save()` or `keras.saving.save_model(model)`. This file format
is considered legacy. We recommend using instead the native Keras
format, e.g. `model.save('my_model.keras')` or
`keras.saving.save_model(model, 'my_model.keras')`.

1334/1334 ━━━━━━━━━━━━━━━━━━━━ 1032s 657ms/step - accuracy: 0.6167 -
loss: 1.0774 - val_accuracy: 0.1917 - val_loss: 4.0015 -
learning_rate: 0.0010
Epoch 2/6
1334/1334 ━━━━━━━━━━━━━━━━━━━━ 0s 608ms/step - accuracy: 0.6818 -
loss: 0.7810

WARNING:absl:You are saving your model as an HDF5 file via
`model.save()` or `keras.saving.save_model(model)`. This file format
is considered legacy. We recommend using instead the native Keras
format, e.g. `model.save('my_model.keras')` or
`keras.saving.save_model(model, 'my_model.keras')`.

1334/1334 ━━━━━━━━━━━━━━━━━━━━ 863s 647ms/step - accuracy: 0.6819 -
loss: 0.7810 - val_accuracy: 0.6659 - val_loss: 0.8579 -
learning_rate: 0.0010
Epoch 3/6
1334/1334 ━━━━━━━━━━━━━━━━━━━━ 860s 645ms/step - accuracy: 0.7274 -
loss: 0.6480 - val_accuracy: 0.4152 - val_loss: 1.4921 -
learning_rate: 0.0010
Epoch 4/6
1334/1334 ━━━━━━━━━━━━━━━━━━━━ 860s 644ms/step - accuracy: 0.7567 -
loss: 0.5955 - val_accuracy: 0.2255 - val_loss: 2.5155 -
learning_rate: 0.0010
Epoch 5/6
1334/1334 ━━━━━━━━━━━━━━━━━━━━ 872s 653ms/step - accuracy: 0.7749 -
loss: 0.5375 - val_accuracy: 0.1844 - val_loss: 2.6119 -
```

```
learning_rate: 5.0000e-04
Epoch 6/6
1334/1334 ━━━━━━━━━━━━━━━━━━━━ 0s 610ms/step - accuracy: 0.7959 -
loss: 0.4917

WARNING:absl:You are saving your model as an HDF5 file via
`model.save()` or `keras.saving.save_model(model)`. This file format
is considered legacy. We recommend using instead the native Keras
format, e.g. `model.save('my_model.keras')` or
`keras.saving.save_model(model, 'my_model.keras')`.

1334/1334 ━━━━━━━━━━━━━━━━━━━━ 866s 649ms/step - accuracy: 0.7959 -
loss: 0.4917 - val_accuracy: 0.7002 - val_loss: 1.0330 -
learning_rate: 5.0000e-04
```

Unfreeze, Finetune and Evaluate the EfficientnetV2S backbone

```python
# Unfreeze and fine-tune
print("\nUnfreezing backbone for fine-tuning...")
for layer in img_model.layers:
    layer.trainable = True

# recompile with lower LR
try:
    opt2 = AdamW(learning_rate=5e-5, weight_decay=1e-6)
except Exception:
    opt2 = tf.keras.optimizers.Adam(learning_rate=5e-5)
img_model.compile(optimizer=opt2, loss='categorical_crossentropy',
metrics=['accuracy'])

print("\nFine-tuning backbone...")
img_model.fit(
    train_ds,
    validation_data=val_ds,
    epochs=12,
    callbacks=[checkpoint, reduce_lr, es, TQDMProgressBar()],
    verbose=0
)
```

```
Unfreezing backbone for fine-tuning...

Fine-tuning backbone...

Training:   0%|          | 0/12 [00:00<?, ?epoch/s]WARNING:absl:You
are saving your model as an HDF5 file via `model.save()` or
`keras.saving.save_model(model)`. This file format is considered
```

```
legacy. We recommend using instead the native Keras format, e.g.
`model.save('my_model.keras')` or `keras.saving.save_model(model,
'my_model.keras')`.
Training:   8%|▊         | 1/12 [16:45<3:04:17, 1005.27s/epoch,
loss=0.4095, acc=0.8303, val_acc=0.8786]WARNING:absl:You are saving
your model as an HDF5 file via `model.save()` or
`keras.saving.save_model(model)`. This file format is considered
legacy. We recommend using instead the native Keras format, e.g.
`model.save('my_model.keras')` or `keras.saving.save_model(model,
'my_model.keras')`.
Training:  17%|█▋        | 2/12 [31:03<2:33:09, 918.97s/epoch,
loss=0.3885, acc=0.8380, val_acc=0.8832] WARNING:absl:You are saving
your model as an HDF5 file via `model.save()` or
`keras.saving.save_model(model)`. This file format is considered
legacy. We recommend using instead the native Keras format, e.g.
`model.save('my_model.keras')` or `keras.saving.save_model(model,
'my_model.keras')`.
Training:  33%|███▎      | 4/12 [59:55<1:57:42, 882.86s/epoch,
loss=0.3700, acc=0.8452, val_acc=0.8808]WARNING:absl:You are saving
your model as an HDF5 file via `model.save()` or
`keras.saving.save_model(model)`. This file format is considered
legacy. We recommend using instead the native Keras format, e.g.
`model.save('my_model.keras')` or `keras.saving.save_model(model,
'my_model.keras')`.
Training:  67%|██████▋   | 8/12 [1:57:24<57:48, 867.06s/epoch,
loss=0.3367, acc=0.8579, val_acc=0.8597]  WARNING:absl:You are saving
your model as an HDF5 file via `model.save()` or
`keras.saving.save_model(model)`. This file format is considered
legacy. We recommend using instead the native Keras format, e.g.
`model.save('my_model.keras')` or `keras.saving.save_model(model,
'my_model.keras')`.
Training:  75%|███████▌  | 9/12 [2:11:44<43:14, 864.79s/epoch,
loss=0.3359, acc=0.8594, val_acc=0.8957]WARNING:absl:You are saving
your model as an HDF5 file via `model.save()` or
`keras.saving.save_model(model)`. This file format is considered
legacy. We recommend using instead the native Keras format, e.g.
`model.save('my_model.keras')` or `keras.saving.save_model(model,
'my_model.keras')`.
Training: 100%|██████████| 12/12 [2:54:55<00:00, 874.64s/epoch,
loss=0.3159, acc=0.8683, val_acc=0.8715]
```

```
<keras.src.callbacks.history.History at 0x7b83ee923450>
```

```
custom_objs = {
    "Cast": tf.cast  # register Cast op for loading
}

# Load best saved img model if exists
best_img = ckpdir / "best_img_model.h5"
```

```python
if best_img.exists():
    with custom_object_scope(custom_objs):
        img_model = tf.keras.models.load_model(str(best_img))
    print("Loaded best image model from checkpoint.")
```

```
WARNING:absl:Compiled the loaded model, but the compiled metrics have
yet to be built. `model.compile_metrics` will be empty until you train
or evaluate the model.

Loaded best image model from checkpoint.
```

```python
# Evaluate on val set
print("\nEvaluating image model on validation set:")
val_preds = img_model.predict(val_ds)
val_pred_labels = val_preds.argmax(axis=1)
y_val_labels = y_val.argmax(axis=1)
print("\nAccuracy:", accuracy_score(y_val_labels, val_pred_labels))
print("Macro F1:", f1_score(y_val_labels, val_pred_labels,
average='macro'))
print("\nClassification Report: ", classification_report(y_val_labels,
val_pred_labels))
```

```
Evaluating image model on validation set:
293/293 ━━━━━━━━━━━━━━━━━━━━ 47s 160ms/step

Accuracy: 0.8998292544109278
Macro F1: 0.8923051186181343

Classification Report:                precision    recall  f1-score
support

           0       0.95      0.92      0.93      1688
           1       0.93      0.86      0.90       501
           2       0.89      0.94      0.91      2660
           3       0.90      0.82      0.86       932
           4       0.85      0.88      0.86      1247

    accuracy                           0.90      7028
   macro avg       0.90      0.88      0.89      7028
weighted avg       0.90      0.90      0.90      7028
```

```python
# Save final image model
img_out = WORK / "efficientnetv2s_coral_clusters.keras"
img_model.save(img_out, include_optimizer=False)
print("Saved image model to:", img_out)
```

```
Saved image model to:
/kaggle/working/efficientnetv2s_coral_clusters.keras
```

Save Overall Model Training Results

```
# -----------------------------
# Save metadata and full report (all metrics)
# -----------------------------

# Convert one-hot validation labels → integer labels
y_val_int = np.argmax(y_val, axis=1)

# Logistic regression accuracy (already computed earlier)
if 'yv_lr' in locals():
    feature_lr_acc = float(accuracy_score(y_val_int, yv_lr))
else:
    feature_lr_acc = None

# -----------------------------
# Image model metrics
# -----------------------------
val_acc         = accuracy_score(y_val_labels, val_pred_labels)
macro_f1        = f1_score(y_val_labels, val_pred_labels,
average='macro')
weighted_f1     = f1_score(y_val_labels, val_pred_labels,
average='weighted')
macro_prec      = precision_score(y_val_labels, val_pred_labels,
average='macro')
weighted_prec   = precision_score(y_val_labels, val_pred_labels,
average='weighted')
macro_recall    = recall_score(y_val_labels, val_pred_labels,
average='macro')
weighted_recall = recall_score(y_val_labels, val_pred_labels,
average='weighted')

# Confusion matrix + full classification report
cm = confusion_matrix(y_val_labels, val_pred_labels)
cls_report = classification_report(y_val_labels, val_pred_labels,
output_dict=True)

# -----------------------------
# Final JSON-compatible report
# -----------------------------
report = {
    "n_samples": int(len(aligned_paths)),
    "n_classes (clusters)": int(n_classes),

    # Feature-based LR (GPU cuML)
    "feature_model_lr_acc": feature_lr_acc,

    # Image model metrics
    "image_model_val_acc": float(val_acc),
    "image_model_macro_f1": float(macro_f1),
```

```python
    "image_model_weighted_f1": float(weighted_f1),
    "image_model_macro_precision": float(macro_prec),
    "image_model_weighted_precision": float(weighted_prec),
    "image_model_macro_recall": float(macro_recall),
    "image_model_weighted_recall": float(weighted_recall),

    # Raw outputs
    "confusion_matrix": cm.tolist(),
    "classification_report": cls_report
}

# Save summary CSV
pd.Series(report).to_csv(WORK /
"efficientnetv2s_training_report_summary.csv")
print("\nSaved summary to
efficientnetv2s_training_report_summary.csv")
print("\nReport:")
report
```

```
Saved summary to efficientnetv2s_training_report_summary.csv

Report:

{'n_samples': 39044,
 'n_classes (clusters)': 5,
 'feature_model_lr_acc': 0.9883323847467274,
 'image_model_val_acc': 0.8998292544109278,
 'image_model_macro_f1': 0.8923051186181343,
 'image_model_weighted_f1': 0.8997202623294729,
 'image_model_macro_precision': 0.9044900627324332,
 'image_model_weighted_precision': 0.9011804019446629,
 'image_model_macro_recall': 0.8820135196662019,
 'image_model_weighted_recall': 0.8998292544109278,
 'confusion_matrix': [[1546, 0, 142, 0, 0],
  [0, 433, 0, 14, 54],
  [73, 0, 2490, 31, 66],
  [0, 10, 87, 761, 74],
  [0, 23, 94, 36, 1094]],
 'classification_report': {'0': {'precision': 0.9549104385423101,
   'recall': 0.9158767772511849,
   'f1-score': 0.934986392500756,
   'support': 1688},
  '1': {'precision': 0.9291845493562232,
   'recall': 0.8642714570858283,
   'f1-score': 0.8955532574974147,
   'support': 501},
  '2': {'precision': 0.8851759687166726,
   'recall': 0.9360902255639098,
   'f1-score': 0.9099214324867532,
   'support': 2660},
  '3': {'precision': 0.9038004750593824,
   'recall': 0.8165236051502146,
   'f1-score': 0.8579481397970687,
   'support': 932},
  '4': {'precision': 0.8493788819875776,
   'recall': 0.8773055332798717,
   'f1-score': 0.8631163708086785,
   'support': 1247},
  'accuracy': 0.8998292544109278,
  'macro avg': {'precision': 0.9044900627324332,
   'recall': 0.8820135196662019,
   'f1-score': 0.8923051186181343,
   'support': 7028},
  'weighted avg': {'precision': 0.9011804019446629,
   'recall': 0.8998292544109278,
   'f1-score': 0.8997202623294729,
   'support': 7028}}}
```

Download the Captured Results

```
!pwd
```

```
/kaggle/working
```

```
!zip -r modeling_results.zip /kaggle/working
```

```
  adding: kaggle/working/ (stored 0%)
  adding: kaggle/working/cluster_distribution_by_source.png (deflated
20%)
  adding: kaggle/working/.virtual_documents/ (stored 0%)
  adding: kaggle/working/efficientnetv2s_coral_clusters.keras
(deflated 9%)
  adding: kaggle/working/metadata_with_clusters.csv (deflated 95%)
  adding: kaggle/working/feature_logreg_pipeline.joblib (deflated 4%)
  adding: kaggle/working/simple_nn_classifier.h5 (deflated 22%)
  adding: kaggle/working/confusion_matrix.png (deflated 21%)
  adding: kaggle/working/efficientnetv2s_training_report_summary.csv
(deflated 60%)
  adding: kaggle/working/coral_dataset_with_clusters_and_metrics.csv
(deflated 96%)
  adding: kaggle/working/img_model_ckpt/ (stored 0%)
  adding: kaggle/working/img_model_ckpt/best_img_model.h5 (deflated
7%)
```

```
!ls -lrth
```

```
total 414M
-rw-r--r-- 1 root root 6.4M Nov 23 01:26 metadata_with_clusters.csv
```

```
-rw-r--r-- 1 root root 8.5M Nov 23 01:26
coral_dataset_with_clusters_and_metrics.csv
-rw-r--r-- 1 root root  57K Nov 23 01:26
cluster_distribution_by_source.png
-rw-r--r-- 1 root root 9.6M Nov 23 01:27 simple_nn_classifier.h5
-rw-r--r-- 1 root root  89K Nov 23 01:27 confusion_matrix.png
-rw-r--r-- 1 root root  31K Nov 23 01:38
feature_logreg_pipeline.joblib
drwxr-xr-x 2 root root 4.0K Nov 23 02:06 img_model_ckpt
-rw-r--r-- 1 root root  82M Nov 23 06:18
efficientnetv2s_coral_clusters.keras
-rw-r--r-- 1 root root 1.4K Nov 23 06:22
efficientnetv2s_training_report_summary.csv
-rw-r--r-- 1 root root 307M Nov 23 06:25 modeling_results.zip
```

```python
from IPython.display import FileLink
FileLink(r'modeling_results.zip')
```

```
/kaggle/working/modeling_results.zip
```