Redes Neuronales y Deep Learning: Proyecto de programación "*Deep Vision in classification tasks*"

ID Group: 07MIAR06

Dataset: Plant Seedlings Classification

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El código de la práctica se encuentra en el siguiente repositorio de GitHub: https://github.com/daniabellan/Plant-Seedlings-Classification

Disclaimer:

Dado que el dataset de Kaggle no presentan etiquetas correspondientes a las imágenes, hemos tomado la decisión de evaluar los modelos en el dataset de validación. Somos conscientes de que no debería ser así en un entorno real, pero no tenemos otra manera de aplicar el performance de los algoritmos y modelos.

Imports Librerías

In [49]:
```
import tensorflow as tf
import os
import pandas as pd
from PIL import Image
import matplotlib.pyplot as plt
from typing import Tuple, Dict
import numpy as np
import math

from sklearn.metrics import classification_report, confusion_matrix
from sklearn.utils.class_weight import compute_class_weight
import tensorflow.keras.applications.efficientnet_v2 as effnV2
from tensorflow.keras.layers import Dense, Concatenate, GlobalMaxPooling2D, GlobalAveragePooling2D, Dropout
```

Descarga de datos desde la plataforma Kaggle

Para este proyecto se va a hacer uso del dataset de kaggle https://www.kaggle.com/c/plant-seedlings-classification/data

En esta ocasión, por dificultades en la descarga directa del dataset desde kaggle, hemos obtado por descargarlo y hacer uso de éste en local.

Dentro del repositorio de Github con el código, en la carpeta de *dataset/* disponemo de dos subcarpetas llamadas *test/* y *train/* con las muestras pertinentes a cada partición. Todo esto es respetando la jerarquía original del dataset.

1. Carga del conjunto de datos

Definimos las funciones necesarias para la carga de los datasets

In [2]:
```
# Definimos un diccionario para mapear los nombres de las clases con sus índices
dict_map_class = {
    'Loose Silky-bent': 0,
    'Common Chickweed': 1,
    'Scentless Mayweed': 2,
    'Small-flowered Cranesbill': 3,
    'Fat Hen': 4,
    'Charlock': 5,
    'Sugar beet': 6,
```

```
    'Cleavers': 7,
    'Black-grass': 8,
    'Shepherds Purse': 9,
    'Common wheat': 10,
    'Maize': 11,
}

# Invertimos el diccioanrio del mapeo de clases
dict_map_class_inverted = {v: k for k, v in dict_map_class.items()}


def get_dict_dataset(
    dataset_path: str = 'dataset'
):
    """
    Crea un diccionario que asigna las rutas de las imágenes a tuplas que contienen la clase y la partición.

    Args:
        dataset_path (str): Ruta al directorio del conjunto de datos. Por defecto, es 'dataset'.

    Returns:
        dict: Un diccionario donde las claves son las rutas de las imágenes y los valores son tuplas (clase, pa
    """

    dict_dataset = {}

    train_classes = os.listdir(os.path.join(dataset_path, 'train'))

    for train_class in train_classes:
        class_path = os.path.join(dataset_path, 'train', train_class)
        train_imgs = os.listdir(class_path)

        # Split Train images to a 80% for a Train Split for each class
        for train_img in train_imgs[:int(len(train_imgs)*0.8)]:
            train_img_path = os.path.join(class_path, train_img)
            dict_dataset[train_img_path] = (dict_map_class[train_class], 'Train')

        # Assign the rest 20% to Valid Split for each class
        for valid_img in train_imgs[int(len(train_imgs)*0.8):]:
            valid_img_path = os.path.join(class_path, valid_img)
            dict_dataset[valid_img_path] = (dict_map_class[train_class], 'Valid')

    # Geting Test Images
    test_path = os.path.join(dataset_path, 'test')
    test_imgs = os.listdir(test_path)

    for test_img in test_imgs:
        test_img_path = os.path.join(test_path, test_img)
        dict_dataset[test_img_path] = ("Unkown", 'Test')

    return dict_dataset


def dict2dataframe(
    input_dict: Dict[str, Tuple]
):
    """
    Convierte un diccionario a un DataFrame de pandas con columnas para 'path', 'label', y 'split'.

    Args:
        input_dict (dict): Un diccionario donde las claves son las rutas de las imágenes y los valores son tupl

    Returns:
        pd.DataFrame: Un DataFrame con columnas 'path', 'label' y 'split'.
    """
    df = pd.DataFrame([(key, values[0], values[1]) for key, values in input_dict.items()], columns=['path', 'la

    # Returns shuffled datasets
    return df.sample(frac=1, random_state=42).reset_index(drop=True)
```

Definimos las funciones para la creación del Datset de TensorFlow

In [3]:

```
def tf_augmenter():
    """
    Devuelve una función de TensorFlow para la aumentación de datos.

    La función devuelta aplica transformaciones aleatorias a las imágenes de entrada,
    incluyendo volteos aleatorios (arriba-abajo y izquierda-derecha), ajustes de brillo aleatorios,
    y ajustes de contraste aleatorios.

    Returns:
        callable: Una función de TensorFlow que toma un número variable de argumentos (tensores)
                  representando el conjunto de datos y aplica aumentación de datos a las imágenes.
    """
    @tf.function
    def f(*dataset):
        output= list(dataset)
```

```
        image = output[0]

        # De manera probabilística, con 50% de que ocurra, se aplicará
        # una de estas transformaciones
        if tf.random.uniform([1], minval=0, maxval=1) > 0.5:
            image = tf.image.random_flip_up_down(image)
        if tf.random.uniform([1], minval=0, maxval=1) > 0.5:
            image = tf.image.random_flip_left_right(image)
        if tf.random.uniform([1], minval=0, maxval=1) > 0.5:
            image = tf.image.random_brightness(image, 0.15)
        if tf.random.uniform([1], minval=0, maxval=1) > 0.7:
            image = tf.image.random_contrast(image, 0.6, 1.4)

        output[0] = image
        return output
    return f


@tf.function
def load_image(*inputs):
    """
    Función de TensorFlow para cargar una imagen utilizando una función de NumPy.

    Args:
        *inputs: Número variable de tensores de entrada.

    Returns:
        list: Una lista de tensores de salida con la imagen cargada como primer elemento.
    """
    outputs = list(inputs)
    image = tf.numpy_function(load_image_np, [inputs[0]], tf.float32)
    image.set_shape([None, None, 3])
    outputs[0] = image

    return outputs


def load_image_np(path):
    """
    Carga una imagen con PIL desde la ruta especificada y la convierte en un array de NumPy.

    Args:
        path (str): La ruta al archivo de la imagen.

    Returns:
        np.ndarray: Un array de NumPy que representa la imagen cargada en formato RGB.
    """
    return np.array(Image.open(path).convert('RGB')).astype(np.float32)


def resize(index=0, resize_to=None):
    """
    Devuelve una función de TensorFlow para cambiar el tamaño de una imagen en un conjunto de datos.

    Args:
        index (int): Índice del tensor de la imagen en el conjunto de datos. Por defecto, es 0.
        resize_to (tuple, list o None): Tamaño objetivo para cambiar el tamaño. Si es None, no se realiza ningú

    Returns:
        callable: Una función de TensorFlow que cambia el tamaño de la imagen en el conjunto de datos.
    """
    def f(*dataset):
        output = list(dataset)
        # Hacemos resize al input size deseado
        resized_image = tf.image.resize(dataset[index], resize_to)
        # Casteamos de nuevo a uint8 para dejar la imagen entre 0 y 255
        resized_image = tf.cast(resized_image, tf.uint8)
        output[index] = resized_image

        return output
    return f


def preprocess_input(index):
    """
    Devuelve una función de TensorFlow para preprocesar una imagen en un conjunto de datos.

    Args:
        index (int): Índice del tensor de la imagen en el conjunto de datos.

    Returns:
        callable: Una función de TensorFlow que preprocesa la imagen en el conjunto de datos.
    """
    @tf.function
    def f(*dataset):
        output = list(dataset)
        image = dataset[index]
        # Convertimos a tf.float32 la imagen
        image = tf.cast(image, tf.float32)
```

```
        # Normalizamos la imagen entre 0 y 1
        image = image / 255.
        output[index] = image

        return output
    return f


def get_dataset(
    df: pd.DataFrame,
    input_size: Tuple[int, int],
    shuffle: bool = False,
    batch_size: int = None,
    gray_scale: bool = False,
    augmenter: bool = False,
    num_aug: int = None,
    test_set: bool = False
)->tf.data.Dataset:
    """
    Crea un dataset de TensorFlow a partir de un DataFrame.

    Args:
        df (pd.DataFrame): DataFrame que contiene información sobre el conjunto de datos.
        input_size (Tuple[int, int]): Tupla que representa el tamaño objetivo para cambiar el tamaño de las imá
        shuffle (bool): Si se debe barajar el conjunto de datos. Por defecto, es False.
        batch_size (int): Tamaño del lote para el conjunto de datos. Si es None, no se realiza agrupamiento. Po
        gray_scale (bool): Si se deben convertir las imágenes a escala de grises. Por defecto, es False.
        augmenter (bool): Si se debe aplicar aumentación de datos. Por defecto, es False.
        num_aug (int): Número de aumentaciones a aplicar si augmenter es True. Por defecto, es None.
        test_set (bool): Si el conjunto de datos es un conjunto de prueba. Por defecto, es False.

    Returns:
        tf.data.Dataset: Un conjunto de datos de TensorFlow preparado según las opciones proporcionadas.
    """
    # Imprimir información sobre la distribución de las etiquetas
    print('Number of instances per label: ',
          pd.Series(df['label']).value_counts(), sep='\n')
    print('\nPercentaje of instances per label: ',
          pd.Series(df['label']).value_counts().div(pd.Series(df['label']).shape[0]),
          sep='\n')

    names = np.array(df['path'], dtype=str)

    if not test_set:
        labels = np.array(tf.keras.utils.to_categorical(df['label'], num_classes=12))
    else:
        labels = np.ones(len(names))

    data = names, labels

    # Creamos un dataet de TensorFlow a partir de las rutas y etiquetas
    dataset = tf.data.Dataset.from_tensor_slices(data)

    # Barajamos el dataset
    if shuffle:
        print(' > Shuffle')
        dataset = dataset.shuffle(len(names))

    # Cargamos las imagenes
    dataset = dataset.map(load_image, num_parallel_calls=tf.data.experimental.AUTOTUNE)

    # Aplicamos el resize
    dataset = dataset.map(resize(resize_to=input_size), num_parallel_calls=tf.data.experimental.AUTOTUNE)

    # Aumentamos los datos
    if augmenter:
        print(f' > Augmentamos datos numero {num_aug}')
        if num_aug == 1:
            dataset = dataset.map(tf_augmenter(), num_parallel_calls=tf.data.experimental.AUTOTUNE)

    # Preprocesamos las entradas
    dataset = dataset.map(preprocess_input(0), num_parallel_calls=tf.data.experimental.AUTOTUNE)

    # Convertimos a escala de grises
    if gray_scale:
        print(' > Escala de grises')
        dataset = dataset.map(lambda *args: (tf.image.rgb_to_grayscale(args[0]), *args[1:]))

    # Definimos el batch size
    if batch_size is not None:
        print(' > Establecemos el batchsize')
        dataset = dataset.batch(batch_size)

    # Prefetch para paralelizar los siguientes batches mientras se evalua un batch
    dataset = dataset.prefetch(tf.data.experimental.AUTOTUNE)

    return dataset
```

Cargamos el dataset en un pd.DataFrame y visualizamos los datos

In [4]:
```
dict_dataset = get_dict_dataset(dataset_path="dataset/")

# Creamos el DataFrame
df_dataset = dict2dataframe(dict_dataset)
df_dataset
```

Out[4]:

	path	label	split
0	dataset/train/Scentless Mayweed/8c496e84a.png	2	Train
1	dataset/train/Common wheat/4a56f32c6.png	10	Train
2	dataset/test/99569b224.png	Unkown	Test
3	dataset/train/Black-grass/e0380dff9.png	8	Valid
4	dataset/train/Fat Hen/9708f9c0e.png	4	Train
...	...	...	...
5539	dataset/train/Shepherds Purse/953ced7c6.png	9	Train
5540	dataset/test/8cf909eb3.png	Unkown	Test
5541	dataset/test/98062cd87.png	Unkown	Test
5542	dataset/test/cc3d2a59a.png	Unkown	Test
5543	dataset/train/Cleavers/b6220c08e.png	7	Train

5544 rows × 3 columns

En el DataFrame anterior podemos visualizar por cada índice, el path de la imagen junto a su etiqueta asociada y al split que perteneces (Train, Valid o Test).

Aquellas imagenes pertenecientes a Test presentan la etiqueta de Unkown. Esto se debe a que el dataset de kaggle no tiene el dataset de test etiquetado, por ello para diferenciarlo aún más le ponemos esta etiqueta.

2. Inspección del conjunto de datos

Dado que ya disponemos del DataFrame con todas las muestras, vamos a crear cada partición y a su vez, visualizar las distribuciones de las etiquetas por cada uno de los splits.

In [5]:
```
# Creamos dataset de Train
df_dataset_train = df_dataset[df_dataset['split'] == 'Train'].drop(columns=['split'])
df_dataset_train
```

Out[5]:

	path	label
0	dataset/train/Scentless Mayweed/8c496e84a.png	2
1	dataset/train/Common wheat/4a56f32c6.png	10
4	dataset/train/Fat Hen/9708f9c0e.png	4
5	dataset/train/Sugar beet/6d623072a.png	6
8	dataset/train/Small-flowered Cranesbill/869252...	3
...	...	...
5534	dataset/train/Scentless Mayweed/948251df3.png	2
5535	dataset/train/Sugar beet/29a0e6bf9.png	6
5537	dataset/train/Charlock/8b35222d0.png	5
5539	dataset/train/Shepherds Purse/953ced7c6.png	9
5543	dataset/train/Cleavers/b6220c08e.png	7

3794 rows × 2 columns

In [6]:
```
# Visualizamos distribuciones por clase
df_dataset_train['label'].value_counts()
```

Out[6]:
```
label
0     523
1     488
2     412
3     396
4     380
5     312
6     308
7     229
8     210
9     184
10    176
11    176
Name: count, dtype: int64
```

Si nos fijamos en la distribución de muestras por clases del splir de train podemos ver como se presenta un desbalanceo de clases notable. Podemos ver como de la clase 0 disponemos de 523 muestras, mientras que de la clase 11 disponemos nomás de 176 muestras.

Dado este desbalanceo, se va a obtar por entrenar los modelos pasándoles los pesos de cada una de las clases mediante el netodo *compute_class_weight()* de la librería de *sklearn*.

Otra opción era duplicar las muestras de las clases minoritarias e igualar las muestras de la mayoritaria, pero esto supondría la repetición de muchas imágenes iguales y se ha descartado

In [7]:
```
# Calculamos los pesos de cada clase debido al desbalanceo de las clases
class_weights = compute_class_weight(class_weight='balanced',
                                     classes=np.unique(df_dataset_train['label'].values),
                                     y=df_dataset_train['label'].values
)

class_weight_dict = dict(enumerate(class_weights))

class_weight_dict
```

Out[7]:
```
{0: 0.6045251752708731,
 1: 0.6478825136612022,
 2: 0.7673948220064725,
 3: 0.7984006734006734,
 4: 0.8320175438596491,
 5: 1.0133547008547008,
 6: 1.0265151515151516,
 7: 1.3806404657933042,
 8: 1.5055555555555555,
 9: 1.7182971014492754,
 10: 1.7964015151515151,
 11: 1.7964015151515151}
```

Por lo que para calcular los pesos de las clases, que posteriormente se les pasarán en el fit del modelo, se hace uso del siguiente código.

Del resultado podemos ver como las clases minoritarias presentan mayor peso que las que tienen mas presencia en nuestro dataset. Por ello, de las clases con mayor peso, la red ponderará más.

Este cálculo de los pesos sólo lo haremos para el set de Train, para los otros no es necesario

In [8]:
```
# Creamos dataset de Validación
df_dataset_valid = df_dataset[df_dataset['split'] == 'Valid'].drop(columns=['split'])
df_dataset_valid
```

Out[8]:

	path	label
3	dataset/train/Black-grass/e0380dff9.png	8
10	dataset/train/Scentless Mayweed/d748c7307.png	2
15	dataset/train/Fat Hen/e6b756e98.png	4
22	dataset/train/Small-flowered Cranesbill/ecf58a...	3
24	dataset/train/Charlock/d1b362c43.png	5
...	...	...
5500	dataset/train/Loose Silky-bent/fc2b27fff.png	0
5501	dataset/train/Charlock/fc3e15a2e.png	5
5503	dataset/train/Scentless Mayweed/d1e775b97.png	2
5505	dataset/train/Common Chickweed/f50c8181a.png	1
5538	dataset/train/Maize/e30accd2f.png	11

956 rows × 2 columns

In [9]:
```
# Visualizamos distribuciones por clase
df_dataset_valid['label'].value_counts()
```

Out[9]:
```
label
0      131
1      123
2      104
3      100
4       95
5       78
6       77
7       58
8       53
9       47
11      45
10      45
Name: count, dtype: int64
```

In [10]:
```
# Creamos dataset de Test
df_dataset_test = df_dataset[df_dataset['split'] == 'Test'].drop(columns=['split'])
df_dataset_test
```

Out[10]:

	path	label
2	dataset/test/99569b224.png	Unkown
6	dataset/test/d14aa43f3.png	Unkown
7	dataset/test/b47691c08.png	Unkown
12	dataset/test/19fdf19fb.png	Unkown
14	dataset/test/7d4cd07ad.png	Unkown
...	...	...
5526	dataset/test/b30ab4659.png	Unkown
5536	dataset/test/bb1c84bbc.png	Unkown
5540	dataset/test/8cf909eb3.png	Unkown
5541	dataset/test/98062cd87.png	Unkown
5542	dataset/test/cc3d2a59a.png	Unkown

794 rows × 2 columns

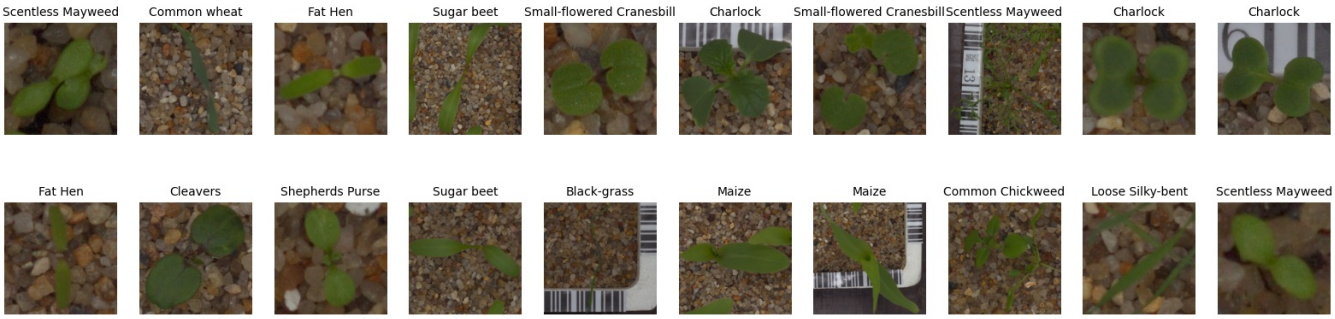
In [11]:
```
# Visualizamos distribuciones por clase
df_dataset_test['label'].value_counts()
```

Out[11]:
```
label
Unkown    794
Name: count, dtype: int64
```

Vistas las distribuciones de muestras por Split, vamos a visualizar unas muestras del Entrenamiento.

In [12]:
```
fig = plt.figure(figsize = (20, 5))

for i in range(20):
    img = Image.open(df_dataset_train.iloc[i]['path'])
    ax = fig.add_subplot(2, 10, i + 1)
    ax.imshow(img.convert('RGB'))
    title = dict_map_class_inverted[df_dataset_train.iloc[i]['label']]
    ax.set_title(title, fontsize=10)
    ax.axis('off')
```



3. Acondicionamiento del conjunto de datos

Creados los Splits para el Dataset original, podemos pasar a preparar un ejemplo de los TensorFlow Datasets pertinentes para cada uno de los Splits (Train, Val y Test) que se van a usar para las siguientes pruebas. A su vez, también los visualizaremos para ver qué imagenes entrarían a la red

In [13]:
```
# Creamos un ejemplo de datastet de train
```

In [13]:
```
# creamos un ejemplo de dataset de train
train_tfdataset = get_dataset(
    df=df_dataset_train,
    input_size=(224,224),
    batch_size=16,
    shuffle=True,
    gray_scale=False,
    augmenter=True,
    num_aug=1,
)

train_tfdataset
```

```
Number of instances per label:
label
0     523
1     488
2     412
3     396
4     380
5     312
6     308
7     229
8     210
9     184
10    176
11    176
Name: count, dtype: int64

Percentaje of instances per label:
label
0     0.137849
1     0.128624
2     0.108593
3     0.104375
4     0.100158
5     0.082235
6     0.081181
7     0.060358
8     0.055351
9     0.048498
10    0.046389
11    0.046389
Name: count, dtype: float64
2023-11-26 18:42:44.832637: I tensorflow/compiler/xla/stream_executor/cuda/cuda_gpu_executor.cc:880] could not
open file to read NUMA node: /sys/bus/pci/devices/0000:06:00.0/numa_node
Your kernel may have been built without NUMA support.
2023-11-26 18:42:44.837225: I tensorflow/compiler/xla/stream_executor/cuda/cuda_gpu_executor.cc:880] could not
open file to read NUMA node: /sys/bus/pci/devices/0000:06:00.0/numa_node
Your kernel may have been built without NUMA support.
2023-11-26 18:42:44.837457: I tensorflow/compiler/xla/stream_executor/cuda/cuda_gpu_executor.cc:880] could not
open file to read NUMA node: /sys/bus/pci/devices/0000:06:00.0/numa_node
Your kernel may have been built without NUMA support.
2023-11-26 18:42:44.840091: I tensorflow/compiler/xla/stream_executor/cuda/cuda_gpu_executor.cc:880] could not
open file to read NUMA node: /sys/bus/pci/devices/0000:06:00.0/numa_node
Your kernel may have been built without NUMA support.
2023-11-26 18:42:44.840385: I tensorflow/compiler/xla/stream_executor/cuda/cuda_gpu_executor.cc:880] could not
open file to read NUMA node: /sys/bus/pci/devices/0000:06:00.0/numa_node
Your kernel may have been built without NUMA support.
2023-11-26 18:42:44.840636: I tensorflow/compiler/xla/stream_executor/cuda/cuda_gpu_executor.cc:880] could not
open file to read NUMA node: /sys/bus/pci/devices/0000:06:00.0/numa_node
Your kernel may have been built without NUMA support.
2023-11-26 18:42:45.186309: I tensorflow/compiler/xla/stream_executor/cuda/cuda_gpu_executor.cc:880] could not
open file to read NUMA node: /sys/bus/pci/devices/0000:06:00.0/numa_node
Your kernel may have been built without NUMA support.
2023-11-26 18:42:45.186661: I tensorflow/compiler/xla/stream_executor/cuda/cuda_gpu_executor.cc:880] could not
open file to read NUMA node: /sys/bus/pci/devices/0000:06:00.0/numa_node
Your kernel may have been built without NUMA support.
2023-11-26 18:42:45.186697: I tensorflow/core/common_runtime/gpu/gpu_device.cc:1977] Could not identify NUMA no
de of platform GPU id 0, defaulting to 0.  Your kernel may not have been built with NUMA support.
2023-11-26 18:42:45.187050: I tensorflow/compiler/xla/stream_executor/cuda/cuda_gpu_executor.cc:880] could not
open file to read NUMA node: /sys/bus/pci/devices/0000:06:00.0/numa_node
Your kernel may have been built without NUMA support.
2023-11-26 18:42:45.187096: I tensorflow/core/common_runtime/gpu/gpu_device.cc:1886] Created device /job:localh
ost/replica:0/task:0/device:GPU:0 with 7551 MB memory:  -> device: 0, name: NVIDIA GeForce RTX 3080, pci bus id
: 0000:06:00.0, compute capability: 8.6
 > Shuffle
 > Augmentamos datos numero 1
 > Establecemos el batchsize
```

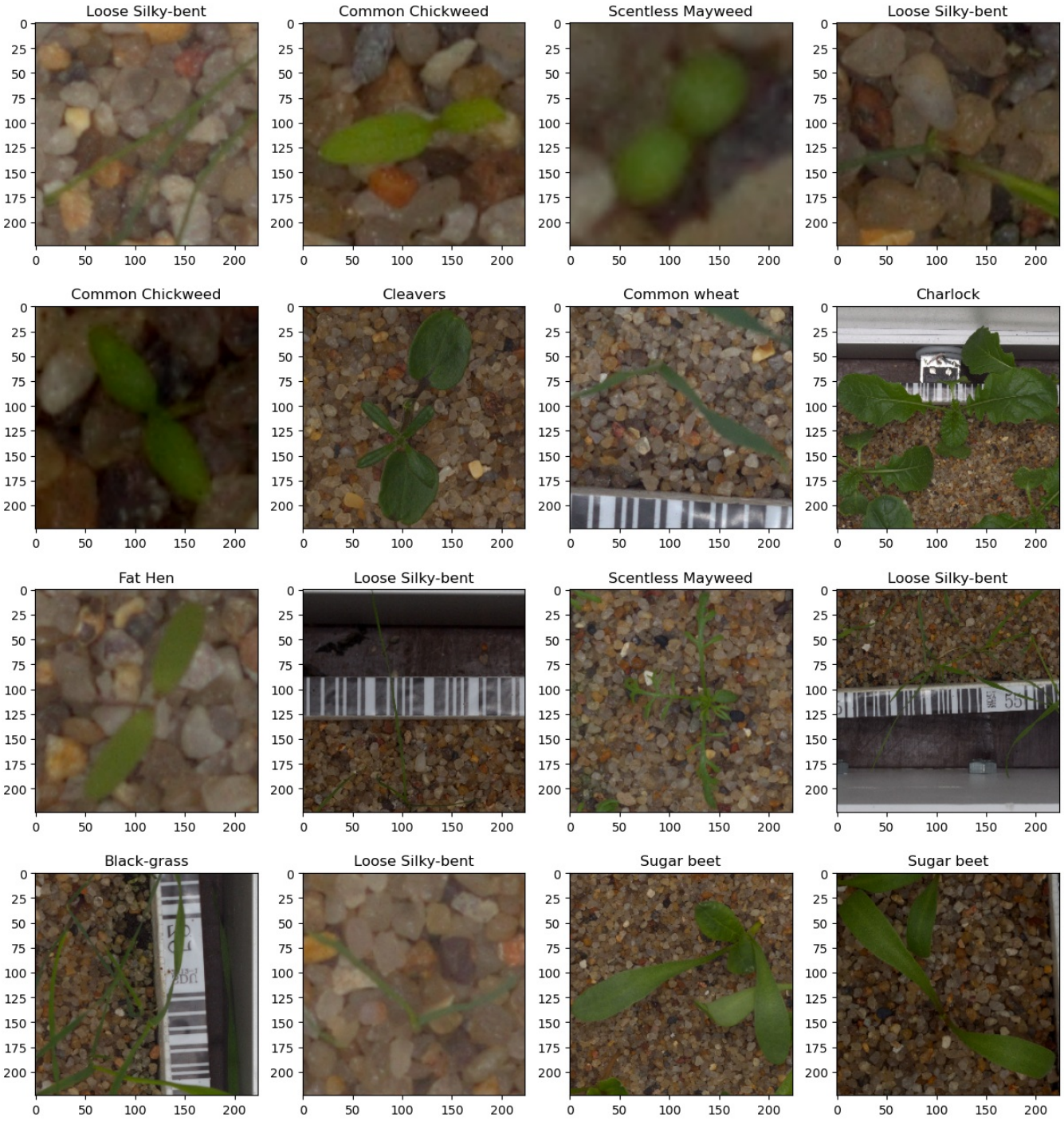
Out[13]:
```
<_PrefetchDataset element_spec=(TensorSpec(shape=(None, 224, 224, 3), dtype=tf.float32, name=None), TensorSpec(
shape=(None, 12), dtype=tf.float32, name=None))>
```

In [14]:
```
# Visualizamos dataset de Train
batch = next(iter(train_tfdataset))

batches_card_np = batch[0].numpy()
y = batch[1].numpy()
images = list(iter(batches_card_np))
```

```
fig, axs = plt.subplots(math.ceil(len(images)/4), 4, figsize=(15, math.ceil(len(images)/4)*4))
axs = axs.ravel()

for i, image in enumerate(images):
    axs[i].imshow(image, cmap='gray')
    title = f"{dict_map_class_inverted[np.argmax(y[i])]}"
    axs[i].set_title(title)
```



In [15]:

```
# Creamos un ejemplo de datastet de Validacion
valid_tfdataset = get_dataset(
    df=df_dataset_valid,
    input_size=(224,224),
    batch_size=16,
    shuffle=True,
    gray_scale=False,
    augmenter=False,
)

valid_tfdataset
```

```
Number of instances per label:
label
0     131
1     123
2     104
3     100
4      95
5      78
6      77
7      58
8      53
9      47
11     45
10     45
Name: count, dtype: int64

Percentaje of instances per label:
label
0     0.137029
1     0.128661
2     0.108787
3     0.104603
4     0.099372
5     0.081590
6     0.080544
7     0.060669
8     0.055439
9     0.049163
11    0.047071
10    0.047071
Name: count, dtype: float64
 > Shuffle
 > Establecemos el batchsize
```

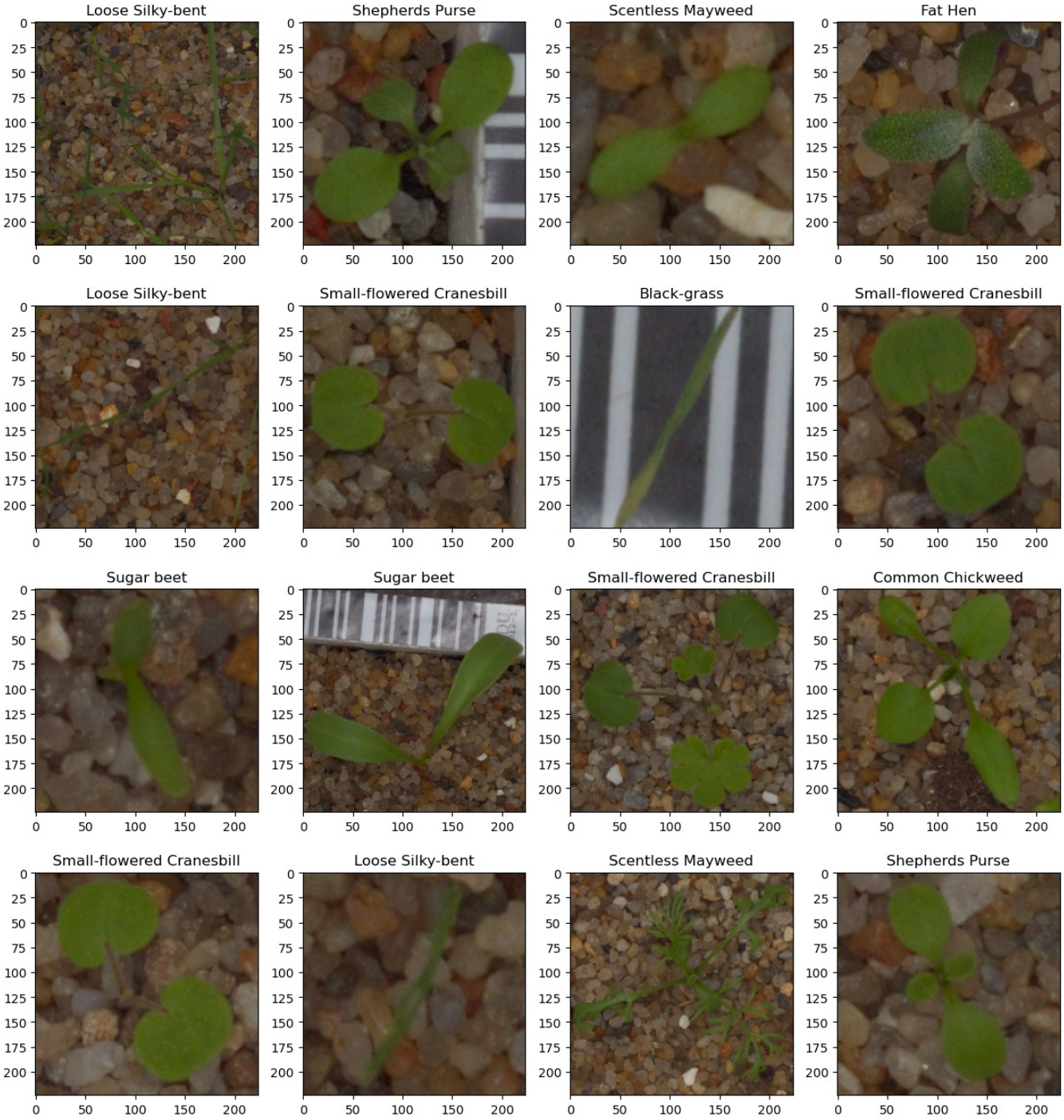
Out[15]:
```
<_PrefetchDataset element_spec=(TensorSpec(shape=(None, 224, 224, 3), dtype=tf.float32, name=None), TensorSpec(
shape=(None, 12), dtype=tf.float32, name=None))>
```

In [16]:
```python
# Visualizamos dataset de Train
batch = next(iter(valid_tfdataset))

batches_card_np = batch[0].numpy()
y = batch[1].numpy()
images = list(iter(batches_card_np))

fig, axs = plt.subplots(math.ceil(len(images)/4), 4, figsize=(15, math.ceil(len(images)/4)*4))
axs = axs.ravel()

for i, image in enumerate(images):
    axs[i].imshow(image, cmap='gray')
    title = f"{dict_map_class_inverted[np.argmax(y[i])]}"
    axs[i].set_title(title)
```



In [17]:
```
# Creamos un ejemplo de datastet de test
test_tfdataset = get_dataset(
    df=df_dataset_test,
    input_size=(224,224),
    batch_size=16,
    gray_scale=False,
    augmenter=False,
    test_set=True,
)

test_tfdataset
```

```
Number of instances per label:
label
Unkown    794
Name: count, dtype: int64

Percentaje of instances per label:
label
Unkown    1.0
Name: count, dtype: float64
 > Establecemos el batchsize
```

Out[17]:
```
<_PrefetchDataset element_spec=(TensorSpec(shape=(None, 224, 224, 3), dtype=tf.float32, name=None), TensorSpec(
shape=(None,), dtype=tf.float64, name=None))>
```

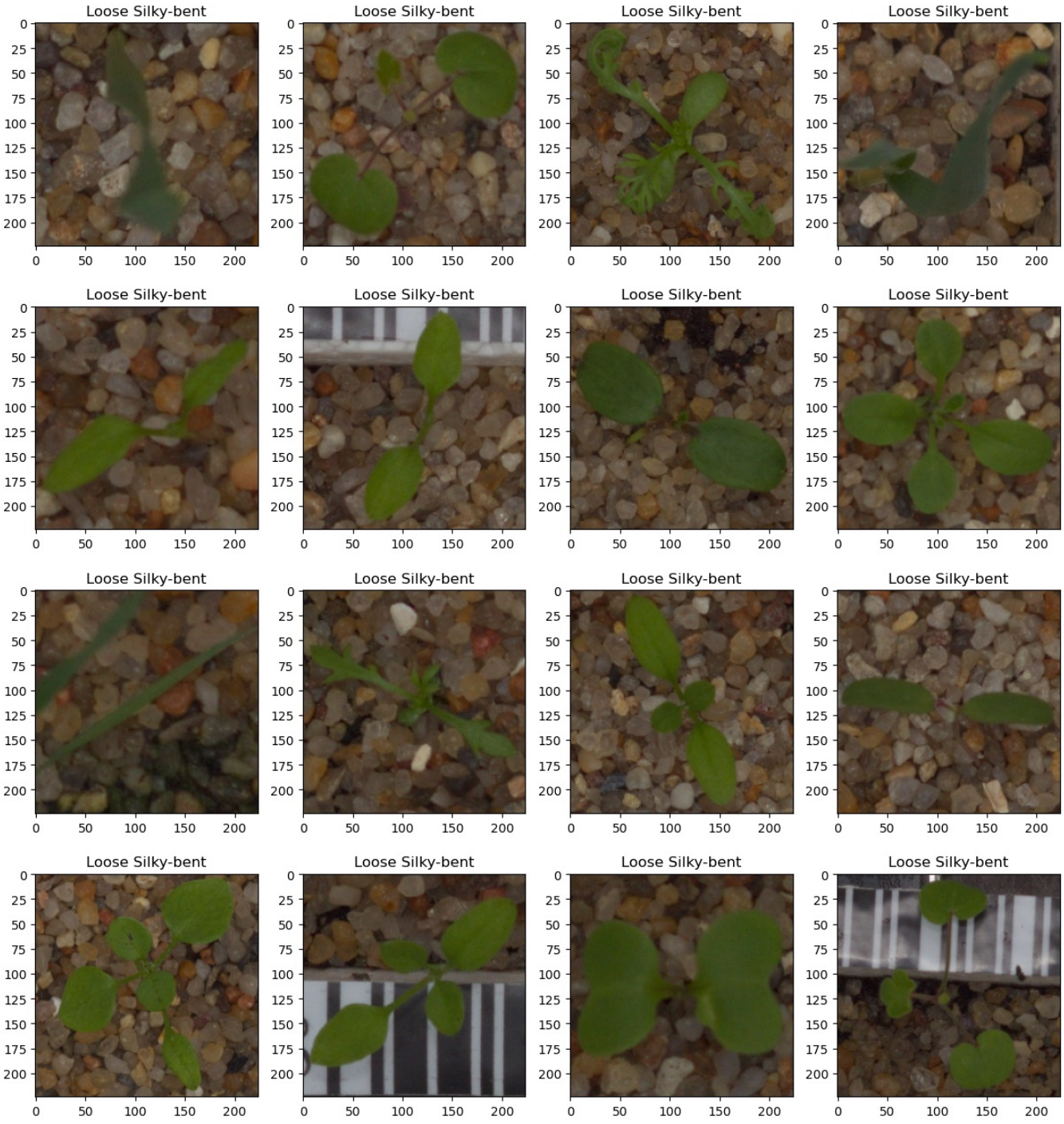
In [18]:
```
# Visualizamos dataset de Test
batch = next(iter(test_tfdataset))

batches_card_np = batch[0].numpy()
y = batch[1].numpy()
```

```
images = list(iter(batches_card_np))

fig, axs = plt.subplots(math.ceil(len(images)/4), 4, figsize=(15, math.ceil(len(images)/4)*4))
axs = axs.ravel()

for i, image in enumerate(images):
    axs[i].imshow(image, cmap='gray')
    title = f"{dict_map_class_inverted[np.argmax(y[i])]}"
    axs[i].set_title(title)
```



4.1 Desarrollo de la arquitectura de red neuronal y entrenamiento de la solución (from scratch)

Creamos los callbacks

In [19]:
```
from tensorflow.keras.callbacks import ModelCheckpoint, EarlyStopping
from tensorflow.keras.callbacks import Callback
import matplotlib
import numpy as np
import matplotlib.pyplot as plt
import pandas as pd

class HistoryAndPlotCallback(Callback):
    def __init__(self, model_name):
        super(HistoryAndPlotCallback, self).__init__()
```

```
        self.model_name = model_name

    def on_train_end(self, logs=None):
        # Guardar el historial del modelo
        history = self.model.history.history

        # Calcular límite eje Y
        loss_av = np.average(history["loss"][-1])
        val_loss_av = np.average(history["val_loss"][-1])
        acc_av = np.average(history["acc"][-1])
        val_acc_av = np.average(history["val_acc"][-1])
        y_upper_limit = np.max([loss_av, val_loss_av, acc_av, val_acc_av])
        y_upper_limit *= 2

        np.save(f'models/{self.model_name}/training_history.npy', history)

        # Guardar métricas y pérdidas en una sola gráfica
        epochs = len(history["loss"])

        plt.style.use("ggplot")
        plt.figure(figsize=(12, 8))
        plt.plot(np.arange(0, epochs), history["loss"], label="train_loss")
        plt.plot(np.arange(0, epochs), history["val_loss"], label="val_loss")
        plt.plot(np.arange(0, epochs), history["acc"], label="train_acc")
        plt.plot(np.arange(0, epochs), history["val_acc"], label="val_acc")

        plt.title(f"Training Loss and Accuracy - {self.model_name}")
        plt.xlabel("Epoch #")
        plt.ylabel("Loss/Accuracy")
        plt.legend(loc='upper left')
        plt.ylim(0, int(y_upper_limit))
        plt.grid(True)

        # Guardar la gráfica
        plt.savefig(f'models/{self.model_name}/training_plot.png')
        plt.close()

        # Guardar history para revisar en el futuro por si se activa un earlystopping o cualquier problema
        pd.DataFrame.from_dict(history).to_csv(f'models/{self.model_name}/history.csv', index=False)


def get_callbacks(model_name):
    callbacks = [
        EarlyStopping(
            monitor = 'val_loss',
            mode = 'min',
            patience = 20,
            verbose=1,
            restore_best_weights=False),
        ModelCheckpoint(
            filepath = f'models/{model_name}',
            monitor = 'val_loss',
            mode = 'min',
            save_best_only = True,
            verbose = 1),
        HistoryAndPlotCallback(model_name),

    ]

    return callbacks
```

Hemos creado Callbacks para almacenar los mejores checkpoints de los modelos a medida que se iban entrenando las redes.

Hemos decidido incluir el EarlyStopping para evitar un sobreentrenamiento y gastar recursos computacionales.

Las métricas a monitorear es el val_loss. Se intenta minimizar en cada época.

También hemos almacenado el historial de entrenamiento para, posteriormente, poder obtener las gráficas. También está añadido el callback para guardar las gráficas después de cada época.

Creamos los datasets para train, val y test

In [20]:
```
print("Dataset Train (TensorFlow):")

train_tfdataset = get_dataset(
    df=df_dataset_train,
    input_size=(224,224),
    batch_size=32,
    shuffle=True,
    gray_scale=False,
    augmenter=True,
    num_aug=1,
)
train_tfdataset
```

```
Dataset Train (TensorFlow):
Number of instances per label:
label
0     523
1     488
2     412
3     396
4     380
5     312
6     308
7     229
8     210
9     184
10    176
11    176
Name: count, dtype: int64

Percentaje of instances per label:
label
0     0.137849
1     0.128624
2     0.108593
3     0.104375
4     0.100158
5     0.082235
6     0.081181
7     0.060358
8     0.055351
9     0.048498
10    0.046389
11    0.046389
Name: count, dtype: float64
 > Shuffle
 > Augmentamos datos numero 1
 > Establecemos el batchsize
```

Out[20]:
```
<_PrefetchDataset element_spec=(TensorSpec(shape=(None, 224, 224, 3), dtype=tf.float32, name=None), TensorSpec(
shape=(None, 12), dtype=tf.float32, name=None))>
```

In [21]:
```
print("Dataset Valid (TensorFlow):")

valid_tfdataset = get_dataset(
    df=df_dataset_valid,
    input_size=(224,224),
    batch_size=32,
    shuffle=False,
    gray_scale=False,
    augmenter=False,
)

valid_tfdataset
```

```
Dataset Valid (TensorFlow):
Number of instances per label:
label
0     131
1     123
2     104
3     100
4      95
5      78
6      77
7      58
8      53
9      47
11     45
10     45
Name: count, dtype: int64

Percentaje of instances per label:
label
0     0.137029
1     0.128661
2     0.108787
3     0.104603
4     0.099372
5     0.081590
6     0.080544
7     0.060669
8     0.055439
9     0.049163
11    0.047071
10    0.047071
Name: count, dtype: float64
 > Establecemos el batchsize
```

Out[21]:
```
<_PrefetchDataset element_spec=(TensorSpec(shape=(None, 224, 224, 3), dtype=tf.float32, name=None), TensorSpec(
shape=(None, 12), dtype=tf.float32, name=None))>
```

In [22]:
```
print("Dataset Test (TensorFlow):")
```

```
test_tfdataset = get_dataset(
    df=df_dataset_test,
    input_size=(224,224),
    batch_size=32,
    gray_scale=False,
    augmenter=False,
    test_set=True,
)

test_tfdataset
```

```
Dataset Test (TensorFlow):
Number of instances per label:
label
Unkown    794
Name: count, dtype: int64

Percentaje of instances per label:
label
Unkown    1.0
Name: count, dtype: float64
 > Establecemos el batchsize
```

Out[22]:
```
<_PrefetchDataset element_spec=(TensorSpec(shape=(None, 224, 224, 3), dtype=tf.float32, name=None), TensorSpec(
shape=(None,), dtype=tf.float64, name=None))>
```

Función para lanzar factoría de modelos from scratch

En este bucle se carga la factoría de modelos from scratch para ir probando cada uno y guardando sus resultados con los callbacks personalizados. Las configuraciones de los modelos vienen desde el archivo "scratch_configs/scratch_experiments.json". Estas configuraciones se pasan a la factoría y se crean los modelos.

In [23]:
```
# model_factory
from tensorflow.keras import models, layers

class ConvBlockConfig:
    def __init__(self, filters, kernel_size, use_maxpooling=True, use_batchnorm=True, dropout_value=0, name=Non
        """Configuracion de cada bloque con los parametros que vienen del json

        Args:
            filters (_type_): Numero de filtros del bloque (una capa convolucional por bloque)
            kernel_size (_type_): Tamaño del kernel de la capa convolucional
            use_maxpooling (bool, optional): Usar regularizacion MaxPooling. Defaults to True.
            use_batchnorm (bool, optional): Usar regularizacion BatchNorm. Defaults to True.
            dropout_value (int, optional): Usar regularizacion Dropout. Defaults to 0.
            name (_type_, optional): Nombre del bloque. Defaults to None.
        """
        self.filters = filters
        self.kernel_size = kernel_size
        self.use_maxpooling = use_maxpooling
        self.use_batchnorm = use_batchnorm
        self.dropout_value = dropout_value
        self.name = name

def create_conv_block(config, input_shape):
    """Crea los bloques convolucionales con sus regularizaciones (MaxPooling, BatchNorm y Dropout)

    Args:
        config (_type_): Configuracion de cada bloque (viene del json de experimentos)
        input_shape (_type_): Tamaño de entrada del bloque

    Returns:
        _type_: Bloque convolucional
    """
    # Creacion del modelo
    block = models.Sequential(name=config.name)

    # CNN input
    block.add(layers.Conv2D(config.filters, config.kernel_size, activation='relu', padding='same', input_shape=

    # Regularizacion
    if config.use_batchnorm:
        block.add(layers.BatchNormalization(name=f'{config.name}_batchnorm'))

    if config.use_maxpooling:
        block.add(layers.MaxPooling2D((2, 2), name=f'{config.name}_maxpooling'))

    if config.dropout_value > 0:
        block.add(layers.Dropout(config.dropout_value))

    return block

def create_model_with_configurations(conv_block_configs, input_shape, num_classes):
    """Crea el modelo en base a los bloques que le hemos pasado con la configuracion de los experimentos

    Args:
        conv_block_configs (_type_): Configuracion de los bloques
        input_shape (_type_): Dimensiones de entrada
```

```
        num_classes (_type_): Numeros de clases para la capa de salida

    Returns:
        _type_: Modelo
    """
    model = models.Sequential()

    # Incluimos la capa de entrada directamente en el modelo principal
    model.add(layers.InputLayer(input_shape=input_shape, name='input'))

    # Creacion de los bloques para la extraccion de caracteristicas
    for i, config in enumerate(conv_block_configs, start=1):
        block = create_conv_block(config, input_shape)
        model.add(block)
        input_shape = (input_shape[0]//2, input_shape[1]//2, config.filters)  # Ajustamos input_shape después d

    # Creacion del top model para obtener la clase
    model.add(layers.Flatten(name='top_model_flatten'))
    model.add(layers.Dense(128, activation='relu', name='top_model_dense_1'))
    #model.add(layers.Dropout(0.5, name='top_model_dropout')) # Opcional
    model.add(layers.Dense(num_classes, activation='softmax', name='top_model_output'))

    return model
```

In [24]:
```
def scratch_train(input_shape, experiment_config:dict):
    # Crear modelo, compilarlo y entrenarlo
    for experiment_name, config in experiment_config.items():
        print(f"Running Experiment: {experiment_name}")

        # Configurar el modelo utilizando las configuraciones
        block_configs = []
        for block_conf in config["model"]["conv_block_configs"]:
            block = ConvBlockConfig(block_conf["filters"],
                                    block_conf["kernel_size"],
                                    block_conf["use_maxpooling"],
                                    block_conf["use_batchnorm"],
                                    block_conf["dropout_value"],
                                    block_conf["name"])
            block_configs.append(block)

        # Crear modelo
        model = create_model_with_configurations(block_configs, input_shape, num_classes)

        # Compilar modelo
        model.compile(
            loss = tf.keras.losses.categorical_crossentropy,
            optimizer = tf.keras.optimizers.Adam(0.0001),
            metrics = ['acc'])

        # Crear callbacks
        callbacks = get_callbacks(experiment_name)

        # Mostrar arquitectura
        print(model.summary())

        # Entrenar modelo
        history = model.fit(train_tfdataset.repeat(),
                            validation_data=valid_tfdataset,
                            class_weight = class_weight_dict,
                            epochs = config["training"]["epochs"],
                            steps_per_epoch=config["training"]["steps_per_epoch"],
                            callbacks = callbacks,
                            verbose=1)
```

5.1 Monitorización del proceso de entrenamiento para la toma de decisiones (from scratch)

Lanzar entrenamiento from scratch

Usando la configuración de los modelos de la factoría, se lanzan todos los experimentos. De esta manera se ejecutan uno detrás de otro sin necesidad de estar pendiente de lanzarlos manualmente. La configuración de todos los experimentos se detalla a continuación:

In [25]:
```
# Configuración experimentos
scratch_experiments = {
    "model1": {
        "model": {
            "conv_block_configs": [
                {
                    "filters": 64,
                    "kernel_size": [3, 3],
                    "use_maxpooling": True,
                    "use_batchnorm": True,
                    "dropout_value": 0.1,
```

```
                "name": "block1"
            },

            {
                "filters": 128,
                "kernel_size": [3, 3],
                "use_maxpooling": True,
                "use_batchnorm": True,
                "dropout_value": 0.1,
                "name": "block2"
            },

            {
                "filters": 256,
                "kernel_size": [3, 3],
                "use_maxpooling": True,
                "use_batchnorm": True,
                "dropout_value": 0.1,
                "name": "block3"
            }
        ]
    },
    "training": {
        "steps_per_epoch": 32,
        "epochs": 50
    }
},

"model1_nobatchnorm": {
    "model": {
        "conv_block_configs": [
            {
                "filters": 64,
                "kernel_size": [3, 3],
                "use_maxpooling": True,
                "use_batchnorm": False,
                "dropout_value": 0.1,
                "name": "block1"
            },
            {
                "filters": 128,
                "kernel_size": [3, 3],
                "use_maxpooling": True,
                "use_batchnorm": False,
                "dropout_value": 0.1,
                "name": "block2"},
            {
                "filters": 256,
                "kernel_size": [3, 3],
                "use_maxpooling": True,
                "use_batchnorm": False,
                "dropout_value": 0.1,
                "name": "block3"
            }
        ]
    },
    "training": {
        "steps_per_epoch": 32,
        "epochs": 50
    }
},

"model2": {
    "model": {
        "conv_block_configs": [
            {
                "filters": 64,
                "kernel_size": [5, 5],
                "use_maxpooling": True,
                "use_batchnorm": True,
                "dropout_value": 0.1,
                "name": "block1"},
            {
                "filters": 128,
                "kernel_size": [5, 5],
                "use_maxpooling": True,
                "use_batchnorm": True,
                "dropout_value": 0.1,
                "name": "block2"
            }
        ]
    },
    "training": {
        "steps_per_epoch": 32,
        "epochs": 50
    }
},

"model2_nobatchnorm": {
```

```
        "model": {
            "conv_block_configs": [
                {
                    "filters": 64,
                    "kernel_size": [5, 5],
                    "use_maxpooling": True,
                    "use_batchnorm": False,
                    "dropout_value": 0.1,
                    "name": "block1"},
                {
                    "filters": 128,
                    "kernel_size": [5, 5],
                    "use_maxpooling": True,
                    "use_batchnorm": False,
                    "dropout_value": 0.1,
                    "name": "block2"
                }
            ]
        },
        "training": {
            "steps_per_epoch": 32,
            "epochs": 50
        }
    },

    "model3": {
        "model": {
            "conv_block_configs": [
                {
                    "filters": 64,
                    "kernel_size": [3, 3],
                    "use_maxpooling": True,
                    "use_batchnorm": True,
                    "dropout_value": 0.1,
                    "name": "block1"
                },
                {
                    "filters": 128,
                    "kernel_size": [3, 3],
                    "use_maxpooling": True,
                    "use_batchnorm": True,
                    "dropout_value": 0.1,
                    "name": "block2"
                },
                {
                    "filters": 256,
                    "kernel_size": [3, 3],
                    "use_maxpooling": True,
                    "use_batchnorm": True,
                    "dropout_value": 0.1,
                    "name": "block3"
                },
                {
                    "filters": 512,
                    "kernel_size": [3, 3],
                    "use_maxpooling": True,
                    "use_batchnorm": True,
                    "dropout_value": 0.1,
                    "name": "block4"
                }
            ]
        },
        "training": {
            "steps_per_epoch": 32,
            "epochs": 50
        }
    },

    "model3_nobatchnorm": {
        "model": {
            "conv_block_configs": [
                {
                    "filters": 64,
                    "kernel_size": [3, 3],
                    "use_maxpooling": True,
                    "use_batchnorm": False,
                    "dropout_value": 0.1,
                    "name": "block1"
                },
                {
                    "filters": 128,
                    "kernel_size": [3, 3],
                    "use_maxpooling": True,
                    "use_batchnorm": False,
                    "dropout_value": 0.1,
                    "name": "block2"
                },
                {
                    "filters": 256,
```

```
                    "kernel_size": [3, 3],
                    "use_maxpooling": True,
                    "use_batchnorm": False,
                    "dropout_value": 0.1,
                    "name": "block3"
                },
                {
                    "filters": 512,
                    "kernel_size": [3, 3],
                    "use_maxpooling": True,
                    "use_batchnorm": False,
                    "dropout_value": 0.1,
                    "name": "block4"
                }
            ]
        },
        "training": {
            "steps_per_epoch": 32,
            "epochs": 50
        }
    }
}
```

In [26]:

```
# Dimensiones de entrada
input_shape = (224, 224, 3)

# Número de clases
num_classes = df_dataset_train["label"].max() + 1

# Lanzar entrenamiento
scratch_train(input_shape, scratch_experiments)
```

```
Running Experiment: model1
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 block1 (Sequential)         (None, 112, 112, 64)      2048

 block2 (Sequential)         (None, 56, 56, 128)       74368

 block3 (Sequential)         (None, 28, 28, 256)       296192

 top_model_flatten (Flatten  (None, 200704)            0
 )

 top_model_dense_1 (Dense)   (None, 128)               25690240

 top_model_output (Dense)    (None, 12)                1548

=================================================================
Total params: 26064396 (99.43 MB)
Trainable params: 26063500 (99.42 MB)
Non-trainable params: 896 (3.50 KB)
_________________________________________________________________
None
Epoch 1/50
2023-11-26 18:42:56.542931: E tensorflow/core/grappler/optimizers/meta_optimizer.cc:961] layout failed: INVALID
_ARGUMENT: Size of values 0 does not match size of permutation 4 @ fanin shape insequential/block1/dropout/drop
out/SelectV2-2-TransposeNHWCToNCHW-LayoutOptimizer
2023-11-26 18:42:57.095623: I tensorflow/compiler/xla/stream_executor/cuda/cuda_dnn.cc:442] Loaded cuDNN versio
n 8700
2023-11-26 18:42:57.397182: I tensorflow/tsl/platform/default/subprocess.cc:304] Start cannot spawn child proce
ss: No such file or directory
2023-11-26 18:42:57.927327: I tensorflow/tsl/platform/default/subprocess.cc:304] Start cannot spawn child proce
ss: No such file or directory
2023-11-26 18:42:58.734794: I tensorflow/compiler/xla/service/service.cc:168] XLA service 0x7f8ca803a590 initia
lized for platform CUDA (this does not guarantee that XLA will be used). Devices:
2023-11-26 18:42:58.734834: I tensorflow/compiler/xla/service/service.cc:176]   StreamExecutor device (0): NVID
IA GeForce RTX 3080, Compute Capability 8.6
2023-11-26 18:42:58.739453: I tensorflow/compiler/mlir/tensorflow/utils/dump_mlir_util.cc:269] disabling MLIR c
rash reproducer, set env var `MLIR_CRASH_REPRODUCER_DIRECTORY` to enable.
2023-11-26 18:42:58.866988: I ./tensorflow/compiler/jit/device_compiler.h:186] Compiled cluster using XLA!  Thi
s line is logged at most once for the lifetime of the process.
 6/32 [====>.....................] - ETA: 2s - loss: 8.9099 - acc: 0.1146WARNING:tensorflow:Callback method
`on_train_batch_end` is slow compared to the batch time (batch time: 0.0357s vs `on_train_batch_end` time: 0.05
94s). Check your callbacks.
32/32 [==============================] - ETA: 0s - loss: 4.8960 - acc: 0.1680
Epoch 1: val_loss improved from inf to 23.67860, saving model to models/model1
INFO:tensorflow:Assets written to: models/model1/assets
INFO:tensorflow:Assets written to: models/model1/assets
```

```
32/32 [==============================] - 18s 380ms/step - loss: 4.8960 - acc: 0.1680 - val_loss: 23.6786 - val_
acc: 0.1287
Epoch 2/50
32/32 [==============================] - ETA: 0s - loss: 2.2053 - acc: 0.2080
Epoch 2: val_loss did not improve from 23.67860
32/32 [==============================] - 9s 291ms/step - loss: 2.2053 - acc: 0.2080 - val_loss: 40.6756 - val_a
cc: 0.1287
Epoch 3/50
32/32 [==============================] - ETA: 0s - loss: 2.1161 - acc: 0.2500
Epoch 3: val_loss did not improve from 23.67860
32/32 [==============================] - 10s 321ms/step - loss: 2.1161 - acc: 0.2500 - val_loss: 50.5102 - val_
acc: 0.1287
Epoch 4/50
32/32 [==============================] - ETA: 0s - loss: 1.9974 - acc: 0.2960
Epoch 4: val_loss did not improve from 23.67860
32/32 [==============================] - 10s 315ms/step - loss: 1.9974 - acc: 0.2960 - val_loss: 54.4386 - val_
acc: 0.1287
Epoch 5/50
32/32 [==============================] - ETA: 0s - loss: 1.9432 - acc: 0.3125
Epoch 5: val_loss did not improve from 23.67860
32/32 [==============================] - 11s 349ms/step - loss: 1.9432 - acc: 0.3125 - val_loss: 57.2173 - val_
acc: 0.1287
Epoch 6/50
32/32 [==============================] - ETA: 0s - loss: 1.7876 - acc: 0.3555
Epoch 6: val_loss did not improve from 23.67860
32/32 [==============================] - 9s 289ms/step - loss: 1.7876 - acc: 0.3555 - val_loss: 51.3227 - val_a
cc: 0.1287
Epoch 7/50
32/32 [==============================] - ETA: 0s - loss: 1.8529 - acc: 0.3701
Epoch 7: val_loss did not improve from 23.67860
32/32 [==============================] - 10s 323ms/step - loss: 1.8529 - acc: 0.3701 - val_loss: 51.2696 - val_
acc: 0.1287
Epoch 8/50
32/32 [==============================] - ETA: 0s - loss: 1.8377 - acc: 0.3554
Epoch 8: val_loss did not improve from 23.67860
32/32 [==============================] - 10s 304ms/step - loss: 1.8377 - acc: 0.3554 - val_loss: 41.3990 - val_
acc: 0.1287
Epoch 9/50
32/32 [==============================] - ETA: 0s - loss: 1.6229 - acc: 0.4189
Epoch 9: val_loss did not improve from 23.67860
32/32 [==============================] - 9s 281ms/step - loss: 1.6229 - acc: 0.4189 - val_loss: 34.6635 - val_a
cc: 0.1287
Epoch 10/50
32/32 [==============================] - ETA: 0s - loss: 1.6856 - acc: 0.4561
Epoch 10: val_loss improved from 23.67860 to 20.57506, saving model to models/model1
INFO:tensorflow:Assets written to: models/model1/assets
INFO:tensorflow:Assets written to: models/model1/assets
32/32 [==============================] - 12s 388ms/step - loss: 1.6856 - acc: 0.4561 - val_loss: 20.5751 - val_
acc: 0.1308
Epoch 11/50
32/32 [==============================] - ETA: 0s - loss: 1.7020 - acc: 0.4141
Epoch 11: val_loss improved from 20.57506 to 11.84752, saving model to models/model1
INFO:tensorflow:Assets written to: models/model1/assets
INFO:tensorflow:Assets written to: models/model1/assets
32/32 [==============================] - 12s 371ms/step - loss: 1.7020 - acc: 0.4141 - val_loss: 11.8475 - val_
acc: 0.1444
Epoch 12/50
32/32 [==============================] - ETA: 0s - loss: 1.4994 - acc: 0.4762
Epoch 12: val_loss improved from 11.84752 to 3.79100, saving model to models/model1
INFO:tensorflow:Assets written to: models/model1/assets
INFO:tensorflow:Assets written to: models/model1/assets
32/32 [==============================] - 13s 397ms/step - loss: 1.4994 - acc: 0.4762 - val_loss: 3.7910 - val_a
cc: 0.3159
Epoch 13/50
32/32 [==============================] - ETA: 0s - loss: 1.5487 - acc: 0.4258
Epoch 13: val_loss improved from 3.79100 to 3.02257, saving model to models/model1
INFO:tensorflow:Assets written to: models/model1/assets
INFO:tensorflow:Assets written to: models/model1/assets
32/32 [==============================] - 13s 408ms/step - loss: 1.5487 - acc: 0.4258 - val_loss: 3.0226 - val_a
cc: 0.3096
Epoch 14/50
32/32 [==============================] - ETA: 0s - loss: 1.5119 - acc: 0.4873
Epoch 14: val_loss improved from 3.02257 to 2.89093, saving model to models/model1
INFO:tensorflow:Assets written to: models/model1/assets
INFO:tensorflow:Assets written to: models/model1/assets
32/32 [==============================] - 13s 404ms/step - loss: 1.5119 - acc: 0.4873 - val_loss: 2.8909 - val_a
cc: 0.2542
Epoch 15/50
32/32 [==============================] - ETA: 0s - loss: 1.4071 - acc: 0.5089
Epoch 15: val_loss did not improve from 2.89093
32/32 [==============================] - 10s 303ms/step - loss: 1.4071 - acc: 0.5089 - val_loss: 3.4234 - val_a
cc: 0.2113
Epoch 16/50
32/32 [==============================] - ETA: 0s - loss: 1.4183 - acc: 0.5322
Epoch 16: val_loss improved from 2.89093 to 2.12441, saving model to models/model1
INFO:tensorflow:Assets written to: models/model1/assets
```

```
INFO:tensorflow:Assets written to: models/model1/assets
32/32 [==============================] - 12s 394ms/step - loss: 1.4183 - acc: 0.5322 - val_loss: 2.1244 - val_a
cc: 0.3023
Epoch 17/50
32/32 [==============================] - ETA: 0s - loss: 1.4387 - acc: 0.5059
Epoch 17: val_loss improved from 2.12441 to 1.81835, saving model to models/model1
INFO:tensorflow:Assets written to: models/model1/assets
INFO:tensorflow:Assets written to: models/model1/assets
32/32 [==============================] - 12s 382ms/step - loss: 1.4387 - acc: 0.5059 - val_loss: 1.8183 - val_a
cc: 0.3421
Epoch 18/50
32/32 [==============================] - ETA: 0s - loss: 1.4313 - acc: 0.5225
Epoch 18: val_loss improved from 1.81835 to 1.68183, saving model to models/model1
INFO:tensorflow:Assets written to: models/model1/assets
INFO:tensorflow:Assets written to: models/model1/assets
32/32 [==============================] - 11s 359ms/step - loss: 1.4313 - acc: 0.5225 - val_loss: 1.6818 - val_a
cc: 0.3860
Epoch 19/50
32/32 [==============================] - ETA: 0s - loss: 1.4047 - acc: 0.5099
Epoch 19: val_loss did not improve from 1.68183
32/32 [==============================] - 10s 327ms/step - loss: 1.4047 - acc: 0.5099 - val_loss: 1.7434 - val_a
cc: 0.4205
Epoch 20/50
32/32 [==============================] - ETA: 0s - loss: 1.2930 - acc: 0.5566
Epoch 20: val_loss improved from 1.68183 to 1.62373, saving model to models/model1
INFO:tensorflow:Assets written to: models/model1/assets
INFO:tensorflow:Assets written to: models/model1/assets
32/32 [==============================] - 11s 358ms/step - loss: 1.2930 - acc: 0.5566 - val_loss: 1.6237 - val_a
cc: 0.4623
Epoch 21/50
32/32 [==============================] - ETA: 0s - loss: 1.3711 - acc: 0.5273
Epoch 21: val_loss improved from 1.62373 to 1.46950, saving model to models/model1
INFO:tensorflow:Assets written to: models/model1/assets
INFO:tensorflow:Assets written to: models/model1/assets
32/32 [==============================] - 12s 375ms/step - loss: 1.3711 - acc: 0.5273 - val_loss: 1.4695 - val_a
cc: 0.5126
Epoch 22/50
32/32 [==============================] - ETA: 0s - loss: 1.3458 - acc: 0.5342
Epoch 22: val_loss did not improve from 1.46950
32/32 [==============================] - 9s 275ms/step - loss: 1.3458 - acc: 0.5342 - val_loss: 1.9755 - val_ac
c: 0.4027
Epoch 23/50
32/32 [==============================] - ETA: 0s - loss: 1.2419 - acc: 0.5624
Epoch 23: val_loss did not improve from 1.46950
32/32 [==============================] - 10s 312ms/step - loss: 1.2419 - acc: 0.5624 - val_loss: 1.5645 - val_a
cc: 0.4833
Epoch 24/50
32/32 [==============================] - ETA: 0s - loss: 1.2066 - acc: 0.5908
Epoch 24: val_loss improved from 1.46950 to 1.44475, saving model to models/model1
INFO:tensorflow:Assets written to: models/model1/assets
INFO:tensorflow:Assets written to: models/model1/assets
32/32 [==============================] - 12s 381ms/step - loss: 1.2066 - acc: 0.5908 - val_loss: 1.4447 - val_a
cc: 0.5356
Epoch 25/50
32/32 [==============================] - ETA: 0s - loss: 1.1184 - acc: 0.6162
Epoch 25: val_loss improved from 1.44475 to 1.30158, saving model to models/model1
INFO:tensorflow:Assets written to: models/model1/assets
INFO:tensorflow:Assets written to: models/model1/assets
32/32 [==============================] - 13s 411ms/step - loss: 1.1184 - acc: 0.6162 - val_loss: 1.3016 - val_a
cc: 0.5628
Epoch 26/50
32/32 [==============================] - ETA: 0s - loss: 1.1335 - acc: 0.6104
Epoch 26: val_loss did not improve from 1.30158
32/32 [==============================] - 8s 266ms/step - loss: 1.1335 - acc: 0.6104 - val_loss: 1.3503 - val_ac
c: 0.5764
Epoch 27/50
32/32 [==============================] - ETA: 0s - loss: 1.1687 - acc: 0.5921
Epoch 27: val_loss did not improve from 1.30158
32/32 [==============================] - 10s 330ms/step - loss: 1.1687 - acc: 0.5921 - val_loss: 1.3236 - val_a
cc: 0.5523
Epoch 28/50
32/32 [==============================] - ETA: 0s - loss: 1.0763 - acc: 0.6299
Epoch 28: val_loss improved from 1.30158 to 1.16862, saving model to models/model1
INFO:tensorflow:Assets written to: models/model1/assets
INFO:tensorflow:Assets written to: models/model1/assets
```

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32/32 [==============================] - 12s 378ms/step - loss: 1.0763 - acc: 0.6299 - val_loss: 1.1686 - val_a
cc: 0.6077
Epoch 29/50
32/32 [==============================] - ETA: 0s - loss: 0.9967 - acc: 0.6396
Epoch 29: val_loss did not improve from 1.16862
32/32 [==============================] - 10s 323ms/step - loss: 0.9967 - acc: 0.6396 - val_loss: 1.3106 - val_a
cc: 0.5994
Epoch 30/50
32/32 [==============================] - ETA: 0s - loss: 0.9920 - acc: 0.6604
Epoch 30: val_loss did not improve from 1.16862
32/32 [==============================] - 9s 294ms/step - loss: 0.9920 - acc: 0.6604 - val_loss: 1.1948 - val_ac
c: 0.6297
Epoch 31/50
32/32 [==============================] - ETA: 0s - loss: 0.9455 - acc: 0.6621
Epoch 31: val_loss did not improve from 1.16862
32/32 [==============================] - 10s 309ms/step - loss: 0.9455 - acc: 0.6621 - val_loss: 1.1806 - val_a
cc: 0.6077
Epoch 32/50
32/32 [==============================] - ETA: 0s - loss: 0.8997 - acc: 0.6885
Epoch 32: val_loss improved from 1.16862 to 1.10771, saving model to models/model1
INFO:tensorflow:Assets written to: models/model1/assets
INFO:tensorflow:Assets written to: models/model1/assets
32/32 [==============================] - 12s 369ms/step - loss: 0.8997 - acc: 0.6885 - val_loss: 1.1077 - val_a
cc: 0.6391
Epoch 33/50
32/32 [==============================] - ETA: 0s - loss: 0.9859 - acc: 0.6797
Epoch 33: val_loss did not improve from 1.10771
32/32 [==============================] - 9s 286ms/step - loss: 0.9859 - acc: 0.6797 - val_loss: 1.2130 - val_ac
c: 0.6130
Epoch 34/50
32/32 [==============================] - ETA: 0s - loss: 0.8005 - acc: 0.7228
Epoch 34: val_loss improved from 1.10771 to 1.06737, saving model to models/model1
INFO:tensorflow:Assets written to: models/model1/assets
INFO:tensorflow:Assets written to: models/model1/assets
32/32 [==============================] - 12s 394ms/step - loss: 0.8005 - acc: 0.7228 - val_loss: 1.0674 - val_a
cc: 0.6642
Epoch 35/50
32/32 [==============================] - ETA: 0s - loss: 0.8011 - acc: 0.7168
Epoch 35: val_loss improved from 1.06737 to 0.98820, saving model to models/model1
INFO:tensorflow:Assets written to: models/model1/assets
INFO:tensorflow:Assets written to: models/model1/assets
32/32 [==============================] - 12s 384ms/step - loss: 0.8011 - acc: 0.7168 - val_loss: 0.9882 - val_a
cc: 0.6987
Epoch 36/50
32/32 [==============================] - ETA: 0s - loss: 0.9371 - acc: 0.7031
Epoch 36: val_loss did not improve from 0.98820
32/32 [==============================] - 10s 305ms/step - loss: 0.9371 - acc: 0.7031 - val_loss: 1.5705 - val_a
cc: 0.5523
Epoch 37/50
32/32 [==============================] - ETA: 0s - loss: 0.9203 - acc: 0.6826
Epoch 37: val_loss did not improve from 0.98820
32/32 [==============================] - 8s 261ms/step - loss: 0.9203 - acc: 0.6826 - val_loss: 1.1190 - val_ac
c: 0.6569
Epoch 38/50
32/32 [==============================] - ETA: 0s - loss: 0.7771 - acc: 0.7168
Epoch 38: val_loss did not improve from 0.98820
32/32 [==============================] - 10s 322ms/step - loss: 0.7771 - acc: 0.7168 - val_loss: 1.2343 - val_a
cc: 0.6506
Epoch 39/50
32/32 [==============================] - ETA: 0s - loss: 0.7867 - acc: 0.7510
Epoch 39: val_loss did not improve from 0.98820
32/32 [==============================] - 10s 310ms/step - loss: 0.7867 - acc: 0.7510 - val_loss: 1.1085 - val_a
cc: 0.6538
Epoch 40/50
32/32 [==============================] - ETA: 0s - loss: 0.7568 - acc: 0.7197
Epoch 40: val_loss did not improve from 0.98820
32/32 [==============================] - 10s 311ms/step - loss: 0.7568 - acc: 0.7197 - val_loss: 1.1238 - val_a
cc: 0.6360
Epoch 41/50
32/32 [==============================] - ETA: 0s - loss: 0.7979 - acc: 0.7396
Epoch 41: val_loss improved from 0.98820 to 0.97991, saving model to models/model1
INFO:tensorflow:Assets written to: models/model1/assets
INFO:tensorflow:Assets written to: models/model1/assets
```

```
32/32 [==============================] - 10s 317ms/step - loss: 0.7979 - acc: 0.7396 - val_loss: 0.9799 - val_a
cc: 0.6946
Epoch 42/50
32/32 [==============================] - ETA: 0s - loss: 0.6619 - acc: 0.7773
Epoch 42: val_loss did not improve from 0.97991
32/32 [==============================] - 10s 301ms/step - loss: 0.6619 - acc: 0.7773 - val_loss: 1.0448 - val_a
cc: 0.6789
Epoch 43/50
32/32 [==============================] - ETA: 0s - loss: 0.5659 - acc: 0.8037
Epoch 43: val_loss did not improve from 0.97991
32/32 [==============================] - 10s 318ms/step - loss: 0.5659 - acc: 0.8037 - val_loss: 1.1211 - val_a
cc: 0.6778
Epoch 44/50
32/32 [==============================] - ETA: 0s - loss: 0.5691 - acc: 0.8018
Epoch 44: val_loss did not improve from 0.97991
32/32 [==============================] - 9s 291ms/step - loss: 0.5691 - acc: 0.8018 - val_loss: 1.0486 - val_ac
c: 0.6778
Epoch 45/50
32/32 [==============================] - ETA: 0s - loss: 0.6078 - acc: 0.8020
Epoch 45: val_loss improved from 0.97991 to 0.92499, saving model to models/model1
INFO:tensorflow:Assets written to: models/model1/assets
INFO:tensorflow:Assets written to: models/model1/assets
32/32 [==============================] - 10s 324ms/step - loss: 0.6078 - acc: 0.8020 - val_loss: 0.9250 - val_a
cc: 0.7312
Epoch 46/50
32/32 [==============================] - ETA: 0s - loss: 0.5549 - acc: 0.8096
Epoch 46: val_loss did not improve from 0.92499
32/32 [==============================] - 10s 313ms/step - loss: 0.5549 - acc: 0.8096 - val_loss: 1.2294 - val_a
cc: 0.6433
Epoch 47/50
32/32 [==============================] - ETA: 0s - loss: 0.6333 - acc: 0.8027
Epoch 47: val_loss did not improve from 0.92499
32/32 [==============================] - 10s 302ms/step - loss: 0.6333 - acc: 0.8027 - val_loss: 0.9724 - val_a
cc: 0.7123
Epoch 48/50
32/32 [==============================] - ETA: 0s - loss: 0.5638 - acc: 0.8047
Epoch 48: val_loss did not improve from 0.92499
32/32 [==============================] - 8s 260ms/step - loss: 0.5638 - acc: 0.8047 - val_loss: 0.9955 - val_ac
c: 0.7134
Epoch 49/50
32/32 [==============================] - ETA: 0s - loss: 0.5466 - acc: 0.8218
Epoch 49: val_loss improved from 0.92499 to 0.89157, saving model to models/model1
INFO:tensorflow:Assets written to: models/model1/assets
INFO:tensorflow:Assets written to: models/model1/assets
32/32 [==============================] - 11s 355ms/step - loss: 0.5466 - acc: 0.8218 - val_loss: 0.8916 - val_a
cc: 0.7103
Epoch 50/50
32/32 [==============================] - ETA: 0s - loss: 0.4633 - acc: 0.8438
Epoch 50: val_loss did not improve from 0.89157
32/32 [==============================] - 9s 293ms/step - loss: 0.4633 - acc: 0.8438 - val_loss: 0.9208 - val_ac
c: 0.7186
Running Experiment: model1_nobatchnorm
Model: "sequential_1"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 block1 (Sequential)         (None, 112, 112, 64)      1792

 block2 (Sequential)         (None, 56, 56, 128)       73856

 block3 (Sequential)         (None, 28, 28, 256)       295168

 top_model_flatten (Flatten  (None, 200704)            0
 )

 top_model_dense_1 (Dense)   (None, 128)               25690240

 top_model_output (Dense)    (None, 12)                1548

=================================================================
Total params: 26062604 (99.42 MB)
Trainable params: 26062604 (99.42 MB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
None
Epoch 1/50
2023-11-26 18:51:47.334375: E tensorflow/core/grappler/optimizers/meta_optimizer.cc:961] layout failed: INVALID
_ARGUMENT: Size of values 0 does not match size of permutation 4 @ fanin shape insequential_1/block1/dropout_3/
dropout/SelectV2-2-TransposeNHWCToNCHW-LayoutOptimizer
 6/32 [====>.........................] - ETA: 2s - loss: 2.6361 - acc: 0.0521WARNING:tensorflow:Callback method
`on_train_batch_end` is slow compared to the batch time (batch time: 0.0357s vs `on_train_batch_end` time: 0.05
14s). Check your callbacks.
WARNING:tensorflow:Callback method `on_train_batch_end` is slow compared to the batch time (batch time: 0.0357s
vs `on_train_batch_end` time: 0.0514s). Check your callbacks.
32/32 [==============================] - ETA: 0s - loss: 2.5038 - acc: 0.0703
Epoch 1: val_loss improved from inf to 2.47914, saving model to models/model1_nobatchnorm
INFO:tensorflow:Assets written to: models/model1_nobatchnorm/assets
```

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INFO:tensorflow:Assets written to: models/model1_nobatchnorm/assets
32/32 [==============================] - 12s 344ms/step - loss: 2.5038 - acc: 0.0703 - val_loss: 2.4791 - val_a
cc: 0.1255
Epoch 2/50
32/32 [==============================] - ETA: 0s - loss: 2.5091 - acc: 0.1143
Epoch 2: val_loss improved from 2.47914 to 2.46177, saving model to models/model1_nobatchnorm
INFO:tensorflow:Assets written to: models/model1_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model1_nobatchnorm/assets
32/32 [==============================] - 11s 348ms/step - loss: 2.5091 - acc: 0.1143 - val_loss: 2.4618 - val_a
cc: 0.0910
Epoch 3/50
32/32 [==============================] - ETA: 0s - loss: 2.3208 - acc: 0.1533
Epoch 3: val_loss improved from 2.46177 to 2.26747, saving model to models/model1_nobatchnorm
INFO:tensorflow:Assets written to: models/model1_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model1_nobatchnorm/assets
32/32 [==============================] - 11s 360ms/step - loss: 2.3208 - acc: 0.1533 - val_loss: 2.2675 - val_a
cc: 0.2427
Epoch 4/50
32/32 [==============================] - ETA: 0s - loss: 2.1349 - acc: 0.2703
Epoch 4: val_loss improved from 2.26747 to 2.04743, saving model to models/model1_nobatchnorm
INFO:tensorflow:Assets written to: models/model1_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model1_nobatchnorm/assets
32/32 [==============================] - 10s 301ms/step - loss: 2.1349 - acc: 0.2703 - val_loss: 2.0474 - val_a
cc: 0.3410
Epoch 5/50
32/32 [==============================] - ETA: 0s - loss: 1.8888 - acc: 0.3135
Epoch 5: val_loss improved from 2.04743 to 1.83637, saving model to models/model1_nobatchnorm
INFO:tensorflow:Assets written to: models/model1_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model1_nobatchnorm/assets
32/32 [==============================] - 11s 338ms/step - loss: 1.8888 - acc: 0.3135 - val_loss: 1.8364 - val_a
cc: 0.3902
Epoch 6/50
32/32 [==============================] - ETA: 0s - loss: 1.8411 - acc: 0.3652
Epoch 6: val_loss improved from 1.83637 to 1.75534, saving model to models/model1_nobatchnorm
INFO:tensorflow:Assets written to: models/model1_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model1_nobatchnorm/assets
32/32 [==============================] - 11s 363ms/step - loss: 1.8411 - acc: 0.3652 - val_loss: 1.7553 - val_a
cc: 0.4006
Epoch 7/50
32/32 [==============================] - ETA: 0s - loss: 1.6808 - acc: 0.3809
Epoch 7: val_loss improved from 1.75534 to 1.56954, saving model to models/model1_nobatchnorm
INFO:tensorflow:Assets written to: models/model1_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model1_nobatchnorm/assets
32/32 [==============================] - 10s 326ms/step - loss: 1.6808 - acc: 0.3809 - val_loss: 1.5695 - val_a
cc: 0.4728
Epoch 8/50
32/32 [==============================] - ETA: 0s - loss: 1.5765 - acc: 0.4653
Epoch 8: val_loss improved from 1.56954 to 1.49639, saving model to models/model1_nobatchnorm
INFO:tensorflow:Assets written to: models/model1_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model1_nobatchnorm/assets
32/32 [==============================] - 12s 373ms/step - loss: 1.5765 - acc: 0.4653 - val_loss: 1.4964 - val_a
cc: 0.5031
Epoch 9/50
32/32 [==============================] - ETA: 0s - loss: 1.4623 - acc: 0.4902
Epoch 9: val_loss improved from 1.49639 to 1.43752, saving model to models/model1_nobatchnorm
INFO:tensorflow:Assets written to: models/model1_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model1_nobatchnorm/assets
32/32 [==============================] - 12s 366ms/step - loss: 1.4623 - acc: 0.4902 - val_loss: 1.4375 - val_a
cc: 0.5209
Epoch 10/50
32/32 [==============================] - ETA: 0s - loss: 1.4658 - acc: 0.5078
Epoch 10: val_loss did not improve from 1.43752
32/32 [==============================] - 9s 293ms/step - loss: 1.4658 - acc: 0.5078 - val_loss: 1.4458 - val_ac
c: 0.4833
Epoch 11/50
32/32 [==============================] - ETA: 0s - loss: 1.3917 - acc: 0.5186
Epoch 11: val_loss did not improve from 1.43752
32/32 [==============================] - 8s 258ms/step - loss: 1.3917 - acc: 0.5186 - val_loss: 1.5015 - val_ac
c: 0.4906
Epoch 12/50
32/32 [==============================] - ETA: 0s - loss: 1.3857 - acc: 0.5139
Epoch 12: val_loss improved from 1.43752 to 1.25642, saving model to models/model1_nobatchnorm
INFO:tensorflow:Assets written to: models/model1_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model1_nobatchnorm/assets
```

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32/32 [==============================] - 11s 364ms/step - loss: 1.3857 - acc: 0.5139 - val_loss: 1.2564 - val_a
cc: 0.5764
Epoch 13/50
32/32 [==============================] - ETA: 0s - loss: 1.2812 - acc: 0.5625
Epoch 13: val_loss did not improve from 1.25642
32/32 [==============================] - 9s 276ms/step - loss: 1.2812 - acc: 0.5625 - val_loss: 1.3371 - val_ac
c: 0.5377
Epoch 14/50
32/32 [==============================] - ETA: 0s - loss: 1.2388 - acc: 0.5732
Epoch 14: val_loss did not improve from 1.25642
32/32 [==============================] - 11s 338ms/step - loss: 1.2388 - acc: 0.5732 - val_loss: 1.3425 - val_a
cc: 0.5481
Epoch 15/50
32/32 [==============================] - ETA: 0s - loss: 1.2128 - acc: 0.5663
Epoch 15: val_loss improved from 1.25642 to 1.18652, saving model to models/model1_nobatchnorm
INFO:tensorflow:Assets written to: models/model1_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model1_nobatchnorm/assets
32/32 [==============================] - 12s 387ms/step - loss: 1.2128 - acc: 0.5663 - val_loss: 1.1865 - val_a
cc: 0.6151
Epoch 16/50
32/32 [==============================] - ETA: 0s - loss: 1.1516 - acc: 0.6035
Epoch 16: val_loss improved from 1.18652 to 1.16294, saving model to models/model1_nobatchnorm
INFO:tensorflow:Assets written to: models/model1_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model1_nobatchnorm/assets
32/32 [==============================] - 11s 360ms/step - loss: 1.1516 - acc: 0.6035 - val_loss: 1.1629 - val_a
cc: 0.6098
Epoch 17/50
32/32 [==============================] - ETA: 0s - loss: 1.1295 - acc: 0.6201
Epoch 17: val_loss did not improve from 1.16294
32/32 [==============================] - 10s 300ms/step - loss: 1.1295 - acc: 0.6201 - val_loss: 1.1732 - val_a
cc: 0.6088
Epoch 18/50
32/32 [==============================] - ETA: 0s - loss: 1.1216 - acc: 0.6123
Epoch 18: val_loss did not improve from 1.16294
32/32 [==============================] - 10s 308ms/step - loss: 1.1216 - acc: 0.6123 - val_loss: 1.2293 - val_a
cc: 0.5889
Epoch 19/50
32/32 [==============================] - ETA: 0s - loss: 1.0590 - acc: 0.6248
Epoch 19: val_loss improved from 1.16294 to 1.03423, saving model to models/model1_nobatchnorm
INFO:tensorflow:Assets written to: models/model1_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model1_nobatchnorm/assets
32/32 [==============================] - 11s 357ms/step - loss: 1.0590 - acc: 0.6248 - val_loss: 1.0342 - val_a
cc: 0.6517
Epoch 20/50
32/32 [==============================] - ETA: 0s - loss: 1.0669 - acc: 0.6338
Epoch 20: val_loss did not improve from 1.03423
32/32 [==============================] - 11s 348ms/step - loss: 1.0669 - acc: 0.6338 - val_loss: 1.0654 - val_a
cc: 0.6308
Epoch 21/50
32/32 [==============================] - ETA: 0s - loss: 1.0440 - acc: 0.6279
Epoch 21: val_loss did not improve from 1.03423
32/32 [==============================] - 10s 316ms/step - loss: 1.0440 - acc: 0.6279 - val_loss: 1.0716 - val_a
cc: 0.6423
Epoch 22/50
32/32 [==============================] - ETA: 0s - loss: 1.0193 - acc: 0.6436
Epoch 22: val_loss improved from 1.03423 to 0.98048, saving model to models/model1_nobatchnorm
INFO:tensorflow:Assets written to: models/model1_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model1_nobatchnorm/assets
32/32 [==============================] - 11s 360ms/step - loss: 1.0193 - acc: 0.6436 - val_loss: 0.9805 - val_a
cc: 0.6778
Epoch 23/50
32/32 [==============================] - ETA: 0s - loss: 0.9751 - acc: 0.6584
Epoch 23: val_loss improved from 0.98048 to 0.96465, saving model to models/model1_nobatchnorm
INFO:tensorflow:Assets written to: models/model1_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model1_nobatchnorm/assets
```

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32/32 [==============================] - 13s 405ms/step - loss: 0.9751 - acc: 0.6584 - val_loss: 0.9646 - val_a
cc: 0.6820
Epoch 24/50
32/32 [==============================] - ETA: 0s - loss: 0.9801 - acc: 0.6543
Epoch 24: val_loss did not improve from 0.96465
32/32 [==============================] - 11s 347ms/step - loss: 0.9801 - acc: 0.6543 - val_loss: 0.9801 - val_a
cc: 0.6799
Epoch 25/50
32/32 [==============================] - ETA: 0s - loss: 0.9979 - acc: 0.6484
Epoch 25: val_loss did not improve from 0.96465
32/32 [==============================] - 10s 311ms/step - loss: 0.9979 - acc: 0.6484 - val_loss: 1.0371 - val_a
cc: 0.6684
Epoch 26/50
32/32 [==============================] - ETA: 0s - loss: 0.9423 - acc: 0.6680
Epoch 26: val_loss did not improve from 0.96465
32/32 [==============================] - 10s 317ms/step - loss: 0.9423 - acc: 0.6680 - val_loss: 1.0283 - val_a
cc: 0.6391
Epoch 27/50
32/32 [==============================] - ETA: 0s - loss: 0.9230 - acc: 0.6772
Epoch 27: val_loss did not improve from 0.96465
32/32 [==============================] - 11s 350ms/step - loss: 0.9230 - acc: 0.6772 - val_loss: 1.0055 - val_a

cc: 0.6370
Epoch 28/50
32/32 [==============================] - ETA: 0s - loss: 0.8002 - acc: 0.7197
Epoch 28: val_loss improved from 0.96465 to 0.93269, saving model to models/model1_nobatchnorm
INFO:tensorflow:Assets written to: models/model1_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model1_nobatchnorm/assets
32/32 [==============================] - 13s 408ms/step - loss: 0.8002 - acc: 0.7197 - val_loss: 0.9327 - val_a
cc: 0.6893
Epoch 29/50
32/32 [==============================] - ETA: 0s - loss: 0.9254 - acc: 0.6855
Epoch 29: val_loss improved from 0.93269 to 0.91702, saving model to models/model1_nobatchnorm
INFO:tensorflow:Assets written to: models/model1_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model1_nobatchnorm/assets
32/32 [==============================] - 11s 337ms/step - loss: 0.9254 - acc: 0.6855 - val_loss: 0.9170 - val_a
cc: 0.6841
Epoch 30/50
32/32 [==============================] - ETA: 0s - loss: 0.8305 - acc: 0.7228
Epoch 30: val_loss did not improve from 0.91702
32/32 [==============================] - 9s 282ms/step - loss: 0.8305 - acc: 0.7228 - val_loss: 0.9328 - val_ac
c: 0.6935
Epoch 31/50
32/32 [==============================] - ETA: 0s - loss: 0.8090 - acc: 0.7158
Epoch 31: val_loss improved from 0.91702 to 0.89510, saving model to models/model1_nobatchnorm
INFO:tensorflow:Assets written to: models/model1_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model1_nobatchnorm/assets
32/32 [==============================] - 12s 371ms/step - loss: 0.8090 - acc: 0.7158 - val_loss: 0.8951 - val_a
cc: 0.6893
Epoch 32/50
32/32 [==============================] - ETA: 0s - loss: 0.8965 - acc: 0.6699
Epoch 32: val_loss did not improve from 0.89510
32/32 [==============================] - 9s 291ms/step - loss: 0.8965 - acc: 0.6699 - val_loss: 0.9176 - val_ac
c: 0.6946
Epoch 33/50
32/32 [==============================] - ETA: 0s - loss: 0.8217 - acc: 0.7461
Epoch 33: val_loss did not improve from 0.89510
32/32 [==============================] - 9s 288ms/step - loss: 0.8217 - acc: 0.7461 - val_loss: 0.9667 - val_ac
c: 0.6559
Epoch 34/50
32/32 [==============================] - ETA: 0s - loss: 0.7842 - acc: 0.7406
Epoch 34: val_loss did not improve from 0.89510
32/32 [==============================] - 9s 274ms/step - loss: 0.7842 - acc: 0.7406 - val_loss: 0.9398 - val_ac
c: 0.6757
Epoch 35/50
32/32 [==============================] - ETA: 0s - loss: 0.7849 - acc: 0.7090
Epoch 35: val_loss improved from 0.89510 to 0.89199, saving model to models/model1_nobatchnorm
INFO:tensorflow:Assets written to: models/model1_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model1_nobatchnorm/assets
32/32 [==============================] - 12s 375ms/step - loss: 0.7849 - acc: 0.7090 - val_loss: 0.8920 - val_a
cc: 0.6977
Epoch 36/50
32/32 [==============================] - ETA: 0s - loss: 0.7142 - acc: 0.7617
Epoch 36: val_loss improved from 0.89199 to 0.86073, saving model to models/model1_nobatchnorm
INFO:tensorflow:Assets written to: models/model1_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model1_nobatchnorm/assets
32/32 [==============================] - 12s 375ms/step - loss: 0.7142 - acc: 0.7617 - val_loss: 0.8607 - val_a
cc: 0.6726
Epoch 37/50
32/32 [==============================] - ETA: 0s - loss: 0.7893 - acc: 0.7275
Epoch 37: val_loss improved from 0.86073 to 0.83864, saving model to models/model1_nobatchnorm
INFO:tensorflow:Assets written to: models/model1_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model1_nobatchnorm/assets
```

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32/32 [==============================] - 11s 342ms/step - loss: 0.7893 - acc: 0.7275 - val_loss: 0.8386 - val_a
cc: 0.6977
Epoch 38/50
32/32 [==============================] - ETA: 0s - loss: 0.8005 - acc: 0.7297
Epoch 38: val_loss did not improve from 0.83864
32/32 [==============================] - 10s 316ms/step - loss: 0.8005 - acc: 0.7297 - val_loss: 0.8842 - val_a
cc: 0.6956
Epoch 39/50
32/32 [==============================] - ETA: 0s - loss: 0.7393 - acc: 0.7295
Epoch 39: val_loss did not improve from 0.83864
32/32 [==============================] - 10s 310ms/step - loss: 0.7393 - acc: 0.7295 - val_loss: 0.8405 - val_a
cc: 0.7165
Epoch 40/50
32/32 [==============================] - ETA: 0s - loss: 0.7113 - acc: 0.7490
Epoch 40: val_loss improved from 0.83864 to 0.79920, saving model to models/model1_nobatchnorm
INFO:tensorflow:Assets written to: models/model1_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model1_nobatchnorm/assets
32/32 [==============================] - 11s 359ms/step - loss: 0.7113 - acc: 0.7490 - val_loss: 0.7992 - val_a
cc: 0.7280
Epoch 41/50
32/32 [==============================] - ETA: 0s - loss: 0.6878 - acc: 0.7703
Epoch 41: val_loss did not improve from 0.79920
32/32 [==============================] - 8s 263ms/step - loss: 0.6878 - acc: 0.7703 - val_loss: 0.8453 - val_ac
c: 0.7144
Epoch 42/50
32/32 [==============================] - ETA: 0s - loss: 0.6176 - acc: 0.7861
Epoch 42: val_loss did not improve from 0.79920
32/32 [==============================] - 9s 293ms/step - loss: 0.6176 - acc: 0.7861 - val_loss: 0.8115 - val_ac
c: 0.7301
Epoch 43/50
32/32 [==============================] - ETA: 0s - loss: 0.6849 - acc: 0.7832
Epoch 43: val_loss improved from 0.79920 to 0.75420, saving model to models/model1_nobatchnorm
INFO:tensorflow:Assets written to: models/model1_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model1_nobatchnorm/assets
```

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32/32 [==============================] - 12s 389ms/step - loss: 0.6849 - acc: 0.7832 - val_loss: 0.7542 - val_a
cc: 0.7395
Epoch 44/50
32/32 [==============================] - ETA: 0s - loss: 0.6177 - acc: 0.7783
Epoch 44: val_loss did not improve from 0.75420
32/32 [==============================] - 10s 324ms/step - loss: 0.6177 - acc: 0.7783 - val_loss: 0.8026 - val_a
cc: 0.7301
Epoch 45/50
32/32 [==============================] - ETA: 0s - loss: 0.6692 - acc: 0.7752
Epoch 45: val_loss did not improve from 0.75420
32/32 [==============================] - 9s 275ms/step - loss: 0.6692 - acc: 0.7752 - val_loss: 0.7734 - val_ac
c: 0.7249
Epoch 46/50
32/32 [==============================] - ETA: 0s - loss: 0.6156 - acc: 0.7783
Epoch 46: val_loss did not improve from 0.75420
32/32 [==============================] - 9s 302ms/step - loss: 0.6156 - acc: 0.7783 - val_loss: 0.7638 - val_ac
c: 0.7479
Epoch 47/50
32/32 [==============================] - ETA: 0s - loss: 0.6681 - acc: 0.7715
Epoch 47: val_loss did not improve from 0.75420
32/32 [==============================] - 9s 294ms/step - loss: 0.6681 - acc: 0.7715 - val_loss: 0.7963 - val_ac
c: 0.7186
Epoch 48/50
32/32 [==============================] - ETA: 0s - loss: 0.6781 - acc: 0.7773
Epoch 48: val_loss did not improve from 0.75420
32/32 [==============================] - 9s 288ms/step - loss: 0.6781 - acc: 0.7773 - val_loss: 0.7790 - val_ac
c: 0.7218
Epoch 49/50
32/32 [==============================] - ETA: 0s - loss: 0.6076 - acc: 0.8020
Epoch 49: val_loss did not improve from 0.75420
32/32 [==============================] - 9s 287ms/step - loss: 0.6076 - acc: 0.8020 - val_loss: 0.8377 - val_ac
c: 0.7228
Epoch 50/50
32/32 [==============================] - ETA: 0s - loss: 0.6214 - acc: 0.7852
Epoch 50: val_loss did not improve from 0.75420
32/32 [==============================] - 10s 317ms/step - loss: 0.6214 - acc: 0.7852 - val_loss: 0.8606 - val_a
cc: 0.7019
Running Experiment: model2
Model: "sequential_2"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 block1 (Sequential)         (None, 112, 112, 64)      5120

 block2 (Sequential)         (None, 56, 56, 128)       205440

 top_model_flatten (Flatten  (None, 401408)            0
 )

 top_model_dense_1 (Dense)   (None, 128)               51380352

 top_model_output (Dense)    (None, 12)                1548

=================================================================
Total params: 51592460 (196.81 MB)
Trainable params: 51592076 (196.81 MB)
Non-trainable params: 384 (1.50 KB)
_________________________________________________________________
None
Epoch 1/50
2023-11-26 19:00:28.375089: E tensorflow/core/grappler/optimizers/meta_optimizer.cc:961] layout failed: INVALID
_ARGUMENT: Size of values 0 does not match size of permutation 4 @ fanin shape insequential_2/block1/dropout_6/
dropout/SelectV2-2-TransposeNHWCToNCHW-LayoutOptimizer
 6/32 [====>.........................] - ETA: 2s - loss: 12.5007 - acc: 0.1198WARNING:tensorflow:Callback metho
d `on_train_batch_end` is slow compared to the batch time (batch time: 0.0383s vs `on_train_batch_end` time: 0.
0636s). Check your callbacks.
WARNING:tensorflow:Callback method `on_train_batch_end` is slow compared to the batch time (batch time: 0.0383s
vs `on_train_batch_end` time: 0.0636s). Check your callbacks.
32/32 [==============================] - ETA: 0s - loss: 7.1232 - acc: 0.1562
Epoch 1: val_loss improved from inf to 5.57673, saving model to models/model2
INFO:tensorflow:Assets written to: models/model2/assets
INFO:tensorflow:Assets written to: models/model2/assets
32/32 [==============================] - 17s 372ms/step - loss: 7.1232 - acc: 0.1562 - val_loss: 5.5767 - val_a
cc: 0.0533
Epoch 2/50
32/32 [==============================] - ETA: 0s - loss: 2.4228 - acc: 0.1611
Epoch 2: val_loss did not improve from 5.57673
32/32 [==============================] - 10s 324ms/step - loss: 2.4228 - acc: 0.1611 - val_loss: 20.5882 - val_
acc: 0.0492
Epoch 3/50
32/32 [==============================] - ETA: 0s - loss: 2.2599 - acc: 0.2256
Epoch 3: val_loss did not improve from 5.57673
32/32 [==============================] - 9s 275ms/step - loss: 2.2599 - acc: 0.2256 - val_loss: 33.1339 - val_a
cc: 0.0492
Epoch 4/50
32/32 [==============================] - ETA: 0s - loss: 2.0791 - acc: 0.2970
Epoch 4: val_loss did not improve from 5.57673
```

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32/32 [==============================] - 10s 320ms/step - loss: 2.0791 - acc: 0.2970 - val_loss: 45.5136 - val_
acc: 0.0492
Epoch 5/50
32/32 [==============================] - ETA: 0s - loss: 2.1298 - acc: 0.2959
Epoch 5: val_loss did not improve from 5.57673
32/32 [==============================] - 10s 317ms/step - loss: 2.1298 - acc: 0.2959 - val_loss: 57.3178 - val_
acc: 0.0492
Epoch 6/50
32/32 [==============================] - ETA: 0s - loss: 2.1541 - acc: 0.2598
Epoch 6: val_loss did not improve from 5.57673
32/32 [==============================] - 10s 320ms/step - loss: 2.1541 - acc: 0.2598 - val_loss: 71.6949 - val_
acc: 0.0492
Epoch 7/50
32/32 [==============================] - ETA: 0s - loss: 2.1057 - acc: 0.3057
Epoch 7: val_loss did not improve from 5.57673
32/32 [==============================] - 8s 269ms/step - loss: 2.1057 - acc: 0.3057 - val_loss: 73.0930 - val_a
cc: 0.0492
Epoch 8/50
32/32 [==============================] - ETA: 0s - loss: 1.9979 - acc: 0.3158
Epoch 8: val_loss did not improve from 5.57673
32/32 [==============================] - 10s 312ms/step - loss: 1.9979 - acc: 0.3158 - val_loss: 71.8086 - val_
acc: 0.0492
Epoch 9/50
32/32 [==============================] - ETA: 0s - loss: 2.0444 - acc: 0.3164
Epoch 9: val_loss did not improve from 5.57673
32/32 [==============================] - 9s 298ms/step - loss: 2.0444 - acc: 0.3164 - val_loss: 77.9839 - val_a
cc: 0.0492
Epoch 10/50
32/32 [==============================] - ETA: 0s - loss: 1.8700 - acc: 0.3672
Epoch 10: val_loss did not improve from 5.57673
32/32 [==============================] - 9s 293ms/step - loss: 1.8700 - acc: 0.3672 - val_loss: 74.8372 - val_a
cc: 0.0492
Epoch 11/50
32/32 [==============================] - ETA: 0s - loss: 2.0050 - acc: 0.3398
Epoch 11: val_loss did not improve from 5.57673
32/32 [==============================] - 8s 265ms/step - loss: 2.0050 - acc: 0.3398 - val_loss: 72.9195 - val_a
cc: 0.0492
Epoch 12/50
32/32 [==============================] - ETA: 0s - loss: 1.9599 - acc: 0.3663
Epoch 12: val_loss did not improve from 5.57673
32/32 [==============================] - 10s 313ms/step - loss: 1.9599 - acc: 0.3663 - val_loss: 60.8676 - val_
acc: 0.0523
Epoch 13/50
32/32 [==============================] - ETA: 0s - loss: 1.9201 - acc: 0.3506
Epoch 13: val_loss did not improve from 5.57673
32/32 [==============================] - 9s 300ms/step - loss: 1.9201 - acc: 0.3506 - val_loss: 56.8206 - val_a
cc: 0.0565
Epoch 14/50
32/32 [==============================] - ETA: 0s - loss: 1.8320 - acc: 0.3945
Epoch 14: val_loss did not improve from 5.57673
32/32 [==============================] - 9s 279ms/step - loss: 1.8320 - acc: 0.3945 - val_loss: 46.8248 - val_a
cc: 0.0994
Epoch 15/50
32/32 [==============================] - ETA: 0s - loss: 1.7505 - acc: 0.4198
Epoch 15: val_loss did not improve from 5.57673
32/32 [==============================] - 9s 276ms/step - loss: 1.7505 - acc: 0.4198 - val_loss: 26.3053 - val_a
cc: 0.1820
Epoch 16/50
32/32 [==============================] - ETA: 0s - loss: 1.7437 - acc: 0.4180
Epoch 16: val_loss did not improve from 5.57673
32/32 [==============================] - 9s 298ms/step - loss: 1.7437 - acc: 0.4180 - val_loss: 14.7768 - val_a
cc: 0.2626
Epoch 17/50
32/32 [==============================] - ETA: 0s - loss: 1.8594 - acc: 0.3711
Epoch 17: val_loss did not improve from 5.57673
32/32 [==============================] - 9s 292ms/step - loss: 1.8594 - acc: 0.3711 - val_loss: 6.6246 - val_ac
c: 0.3201
Epoch 18/50
32/32 [==============================] - ETA: 0s - loss: 1.8780 - acc: 0.3828
Epoch 18: val_loss did not improve from 5.57673
32/32 [==============================] - 10s 306ms/step - loss: 1.8780 - acc: 0.3828 - val_loss: 10.5788 - val_
acc: 0.2636
Epoch 19/50
32/32 [==============================] - ETA: 0s - loss: 1.7201 - acc: 0.4178
Epoch 19: val_loss improved from 5.57673 to 4.40921, saving model to models/model2
INFO:tensorflow:Assets written to: models/model2/assets
INFO:tensorflow:Assets written to: models/model2/assets
32/32 [==============================] - 11s 356ms/step - loss: 1.7201 - acc: 0.4178 - val_loss: 4.4092 - val_a
cc: 0.3619
Epoch 20/50
32/32 [==============================] - ETA: 0s - loss: 1.6566 - acc: 0.4639
Epoch 20: val_loss improved from 4.40921 to 3.08332, saving model to models/model2
INFO:tensorflow:Assets written to: models/model2/assets
INFO:tensorflow:Assets written to: models/model2/assets
```

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32/32 [==============================] - 12s 390ms/step - loss: 1.6566 - acc: 0.4639 - val_loss: 3.0833 - val_a
cc: 0.3180
Epoch 21/50
32/32 [==============================] - ETA: 0s - loss: 1.7541 - acc: 0.4219
Epoch 21: val_loss improved from 3.08332 to 2.98711, saving model to models/model2
INFO:tensorflow:Assets written to: models/model2/assets
INFO:tensorflow:Assets written to: models/model2/assets
32/32 [==============================] - 13s 402ms/step - loss: 1.7541 - acc: 0.4219 - val_loss: 2.9871 - val_a
cc: 0.4048
Epoch 22/50
32/32 [==============================] - ETA: 0s - loss: 1.5635 - acc: 0.4844
Epoch 22: val_loss improved from 2.98711 to 2.98685, saving model to models/model2
INFO:tensorflow:Assets written to: models/model2/assets
INFO:tensorflow:Assets written to: models/model2/assets
32/32 [==============================] - 11s 352ms/step - loss: 1.5635 - acc: 0.4844 - val_loss: 2.9868 - val_a
cc: 0.3985
Epoch 23/50
32/32 [==============================] - ETA: 0s - loss: 1.5543 - acc: 0.4842
Epoch 23: val_loss improved from 2.98685 to 1.91801, saving model to models/model2
INFO:tensorflow:Assets written to: models/model2/assets
INFO:tensorflow:Assets written to: models/model2/assets
32/32 [==============================] - 13s 404ms/step - loss: 1.5543 - acc: 0.4842 - val_loss: 1.9180 - val_a
cc: 0.4477
Epoch 24/50
32/32 [==============================] - ETA: 0s - loss: 1.7237 - acc: 0.4316
Epoch 24: val_loss improved from 1.91801 to 1.71955, saving model to models/model2
INFO:tensorflow:Assets written to: models/model2/assets
INFO:tensorflow:Assets written to: models/model2/assets
32/32 [==============================] - 12s 374ms/step - loss: 1.7237 - acc: 0.4316 - val_loss: 1.7196 - val_a
cc: 0.4372
Epoch 25/50
32/32 [==============================] - ETA: 0s - loss: 1.6197 - acc: 0.4512
Epoch 25: val_loss did not improve from 1.71955
32/32 [==============================] - 10s 310ms/step - loss: 1.6197 - acc: 0.4512 - val_loss: 1.8349 - val_a
cc: 0.4508
Epoch 26/50
32/32 [==============================] - ETA: 0s - loss: 1.5853 - acc: 0.4756
Epoch 26: val_loss did not improve from 1.71955
32/32 [==============================] - 8s 267ms/step - loss: 1.5853 - acc: 0.4756 - val_loss: 1.7392 - val_ac
c: 0.4644
Epoch 27/50
32/32 [==============================] - ETA: 0s - loss: 1.4248 - acc: 0.5228
Epoch 27: val_loss did not improve from 1.71955
32/32 [==============================] - 10s 327ms/step - loss: 1.4248 - acc: 0.5228 - val_loss: 2.2236 - val_a
cc: 0.4435
Epoch 28/50
32/32 [==============================] - ETA: 0s - loss: 1.5871 - acc: 0.5000
Epoch 28: val_loss improved from 1.71955 to 1.61978, saving model to models/model2
INFO:tensorflow:Assets written to: models/model2/assets
INFO:tensorflow:Assets written to: models/model2/assets
32/32 [==============================] - 11s 349ms/step - loss: 1.5871 - acc: 0.5000 - val_loss: 1.6198 - val_a
cc: 0.4843
Epoch 29/50
32/32 [==============================] - ETA: 0s - loss: 1.5534 - acc: 0.4746
Epoch 29: val_loss did not improve from 1.61978
32/32 [==============================] - 11s 331ms/step - loss: 1.5534 - acc: 0.4746 - val_loss: 2.1577 - val_a
cc: 0.4446
Epoch 30/50
32/32 [==============================] - ETA: 0s - loss: 1.6341 - acc: 0.4752
Epoch 30: val_loss did not improve from 1.61978
32/32 [==============================] - 8s 261ms/step - loss: 1.6341 - acc: 0.4752 - val_loss: 2.3297 - val_ac
c: 0.3400
Epoch 31/50
32/32 [==============================] - ETA: 0s - loss: 1.4866 - acc: 0.5205
Epoch 31: val_loss did not improve from 1.61978
32/32 [==============================] - 11s 335ms/step - loss: 1.4866 - acc: 0.5205 - val_loss: 2.3023 - val_a
cc: 0.4435
Epoch 32/50
32/32 [==============================] - ETA: 0s - loss: 1.3802 - acc: 0.5645
Epoch 32: val_loss did not improve from 1.61978
32/32 [==============================] - 9s 297ms/step - loss: 1.3802 - acc: 0.5645 - val_loss: 1.7762 - val_ac
c: 0.5042
Epoch 33/50
32/32 [==============================] - ETA: 0s - loss: 1.4685 - acc: 0.5098
Epoch 33: val_loss did not improve from 1.61978
32/32 [==============================] - 9s 276ms/step - loss: 1.4685 - acc: 0.5098 - val_loss: 1.9977 - val_ac
c: 0.4644
Epoch 34/50
32/32 [==============================] - ETA: 0s - loss: 1.3240 - acc: 0.6010
Epoch 34: val_loss did not improve from 1.61978
32/32 [==============================] - 9s 289ms/step - loss: 1.3240 - acc: 0.6010 - val_loss: 1.9059 - val_ac
c: 0.4812
Epoch 35/50
32/32 [==============================] - ETA: 0s - loss: 1.4386 - acc: 0.5498
Epoch 35: val_loss did not improve from 1.61978
32/32 [==============================] - 10s 310ms/step - loss: 1.4386 - acc: 0.5498 - val_loss: 4.5071 - val_a
cc: 0.3211
```

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Epoch 36/50
32/32 [==============================] - ETA: 0s - loss: 1.3399 - acc: 0.5791
Epoch 36: val_loss did not improve from 1.61978
32/32 [==============================] - 9s 294ms/step - loss: 1.3399 - acc: 0.5791 - val_loss: 5.0827 - val_ac
c: 0.3588
Epoch 37/50
32/32 [==============================] - ETA: 0s - loss: 1.3553 - acc: 0.5703
Epoch 37: val_loss did not improve from 1.61978
32/32 [==============================] - 8s 256ms/step - loss: 1.3553 - acc: 0.5703 - val_loss: 2.5434 - val_ac
c: 0.4195
Epoch 38/50
32/32 [==============================] - ETA: 0s - loss: 1.2768 - acc: 0.6000
Epoch 38: val_loss did not improve from 1.61978
32/32 [==============================] - 9s 285ms/step - loss: 1.2768 - acc: 0.6000 - val_loss: 1.9664 - val_ac
c: 0.5324
Epoch 39/50
32/32 [==============================] - ETA: 0s - loss: 1.2683 - acc: 0.5791
Epoch 39: val_loss did not improve from 1.61978
32/32 [==============================] - 10s 308ms/step - loss: 1.2683 - acc: 0.5791 - val_loss: 2.0091 - val_a
cc: 0.5031
Epoch 40/50
32/32 [==============================] - ETA: 0s - loss: 1.3099 - acc: 0.6016
Epoch 40: val_loss did not improve from 1.61978
32/32 [==============================] - 9s 296ms/step - loss: 1.3099 - acc: 0.6016 - val_loss: 1.7055 - val_ac
c: 0.5251
Epoch 41/50
32/32 [==============================] - ETA: 0s - loss: 1.2564 - acc: 0.5921
Epoch 41: val_loss did not improve from 1.61978
32/32 [==============================] - 8s 264ms/step - loss: 1.2564 - acc: 0.5921 - val_loss: 2.1295 - val_ac
c: 0.4833
Epoch 42/50
32/32 [==============================] - ETA: 0s - loss: 1.2293 - acc: 0.6152
Epoch 42: val_loss did not improve from 1.61978
32/32 [==============================] - 10s 325ms/step - loss: 1.2293 - acc: 0.6152 - val_loss: 1.8648 - val_a
cc: 0.5031
Epoch 43/50
32/32 [==============================] - ETA: 0s - loss: 1.3526 - acc: 0.5732
Epoch 43: val_loss did not improve from 1.61978
32/32 [==============================] - 9s 282ms/step - loss: 1.3526 - acc: 0.5732 - val_loss: 1.9601 - val_ac
c: 0.5042
Epoch 44/50
32/32 [==============================] - ETA: 0s - loss: 1.1425 - acc: 0.6426
Epoch 44: val_loss did not improve from 1.61978
32/32 [==============================] - 9s 281ms/step - loss: 1.1425 - acc: 0.6426 - val_loss: 2.3777 - val_ac
c: 0.4404
Epoch 45/50
32/32 [==============================] - ETA: 0s - loss: 1.2669 - acc: 0.5772
Epoch 45: val_loss did not improve from 1.61978
32/32 [==============================] - 9s 272ms/step - loss: 1.2669 - acc: 0.5772 - val_loss: 2.0723 - val_ac
c: 0.5010
Epoch 46/50
32/32 [==============================] - ETA: 0s - loss: 1.2712 - acc: 0.5977
Epoch 46: val_loss did not improve from 1.61978
32/32 [==============================] - 10s 312ms/step - loss: 1.2712 - acc: 0.5977 - val_loss: 1.6315 - val_a
cc: 0.5272
Epoch 47/50
32/32 [==============================] - ETA: 0s - loss: 1.2668 - acc: 0.5977
Epoch 47: val_loss improved from 1.61978 to 1.53502, saving model to models/model2
INFO:tensorflow:Assets written to: models/model2/assets
INFO:tensorflow:Assets written to: models/model2/assets
32/32 [==============================] - 12s 391ms/step - loss: 1.2668 - acc: 0.5977 - val_loss: 1.5350 - val_a
cc: 0.5826
Epoch 48/50
32/32 [==============================] - ETA: 0s - loss: 1.2746 - acc: 0.5928
Epoch 48: val_loss improved from 1.53502 to 1.41117, saving model to models/model2
INFO:tensorflow:Assets written to: models/model2/assets
INFO:tensorflow:Assets written to: models/model2/assets
```

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32/32 [==============================] - 11s 361ms/step - loss: 1.2746 - acc: 0.5928 - val_loss: 1.4112 - val_a
cc: 0.5513
Epoch 49/50
32/32 [==============================] - ETA: 0s - loss: 1.1052 - acc: 0.6426
Epoch 49: val_loss did not improve from 1.41117
32/32 [==============================] - 10s 329ms/step - loss: 1.1052 - acc: 0.6426 - val_loss: 1.5615 - val_a
cc: 0.5701
Epoch 50/50
32/32 [==============================] - ETA: 0s - loss: 1.0745 - acc: 0.6504
Epoch 50: val_loss did not improve from 1.41117
32/32 [==============================] - 9s 295ms/step - loss: 1.0745 - acc: 0.6504 - val_loss: 1.7007 - val_ac
c: 0.5596
Running Experiment: model2_nobatchnorm
Model: "sequential_3"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 block1 (Sequential)         (None, 112, 112, 64)      4864

 block2 (Sequential)         (None, 56, 56, 128)       204928

 top_model_flatten (Flatten  (None, 401408)            0
 )

 top_model_dense_1 (Dense)   (None, 128)               51380352

 top_model_output (Dense)    (None, 12)                1548

=================================================================
Total params: 51591692 (196.81 MB)
Trainable params: 51591692 (196.81 MB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
None
Epoch 1/50
2023-11-26 19:08:45.971982: E tensorflow/core/grappler/optimizers/meta_optimizer.cc:961] layout failed: INVALID
_ARGUMENT: Size of values 0 does not match size of permutation 4 @ fanin shape insequential_3/block1/dropout_8/
dropout/SelectV2-2-TransposeNHWCToNCHW-LayoutOptimizer
 6/32 [====>.....................] - ETA: 3s - loss: 2.8470 - acc: 0.0469WARNING:tensorflow:Callback method
`on_train_batch_end` is slow compared to the batch time (batch time: 0.0443s vs `on_train_batch_end` time: 0.05
98s). Check your callbacks.
WARNING:tensorflow:Callback method `on_train_batch_end` is slow compared to the batch time (batch time: 0.0443s
vs `on_train_batch_end` time: 0.0598s). Check your callbacks.
32/32 [==============================] - ETA: 0s - loss: 2.5654 - acc: 0.0723
Epoch 1: val_loss improved from inf to 2.47979, saving model to models/model2_nobatchnorm
INFO:tensorflow:Assets written to: models/model2_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model2_nobatchnorm/assets
32/32 [==============================] - 14s 399ms/step - loss: 2.5654 - acc: 0.0723 - val_loss: 2.4798 - val_a
cc: 0.1046
Epoch 2/50
32/32 [==============================] - ETA: 0s - loss: 2.5112 - acc: 0.0986
Epoch 2: val_loss improved from 2.47979 to 2.44516, saving model to models/model2_nobatchnorm
INFO:tensorflow:Assets written to: models/model2_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model2_nobatchnorm/assets
32/32 [==============================] - 11s 357ms/step - loss: 2.5112 - acc: 0.0986 - val_loss: 2.4452 - val_a
cc: 0.1067
Epoch 3/50
32/32 [==============================] - ETA: 0s - loss: 2.3284 - acc: 0.1396
Epoch 3: val_loss improved from 2.44516 to 2.35855, saving model to models/model2_nobatchnorm
INFO:tensorflow:Assets written to: models/model2_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model2_nobatchnorm/assets
32/32 [==============================] - 12s 386ms/step - loss: 2.3284 - acc: 0.1396 - val_loss: 2.3586 - val_a
cc: 0.1433
Epoch 4/50
32/32 [==============================] - ETA: 0s - loss: 2.3528 - acc: 0.1238
Epoch 4: val_loss improved from 2.35855 to 2.27866, saving model to models/model2_nobatchnorm
INFO:tensorflow:Assets written to: models/model2_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model2_nobatchnorm/assets
32/32 [==============================] - 11s 336ms/step - loss: 2.3528 - acc: 0.1238 - val_loss: 2.2787 - val_a
cc: 0.1412
Epoch 5/50
32/32 [==============================] - ETA: 0s - loss: 2.2192 - acc: 0.1729
Epoch 5: val_loss improved from 2.27866 to 2.11659, saving model to models/model2_nobatchnorm
INFO:tensorflow:Assets written to: models/model2_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model2_nobatchnorm/assets
32/32 [==============================] - 12s 383ms/step - loss: 2.2192 - acc: 0.1729 - val_loss: 2.1166 - val_a
cc: 0.2563
Epoch 6/50
32/32 [==============================] - ETA: 0s - loss: 1.9854 - acc: 0.2686
Epoch 6: val_loss improved from 2.11659 to 1.92883, saving model to models/model2_nobatchnorm
INFO:tensorflow:Assets written to: models/model2_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model2_nobatchnorm/assets
```

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32/32 [==============================] - 12s 376ms/step - loss: 1.9854 - acc: 0.2686 - val_loss: 1.9288 - val_a
cc: 0.3358
Epoch 7/50
32/32 [==============================] - ETA: 0s - loss: 1.9476 - acc: 0.3193
Epoch 7: val_loss improved from 1.92883 to 1.87172, saving model to models/model2_nobatchnorm
INFO:tensorflow:Assets written to: models/model2_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model2_nobatchnorm/assets
32/32 [==============================] - 11s 359ms/step - loss: 1.9476 - acc: 0.3193 - val_loss: 1.8717 - val_a
cc: 0.3609
Epoch 8/50
32/32 [==============================] - ETA: 0s - loss: 1.8472 - acc: 0.3455
Epoch 8: val_loss improved from 1.87172 to 1.72532, saving model to models/model2_nobatchnorm
INFO:tensorflow:Assets written to: models/model2_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model2_nobatchnorm/assets
32/32 [==============================] - 12s 389ms/step - loss: 1.8472 - acc: 0.3455 - val_loss: 1.7253 - val_a
cc: 0.3724
Epoch 9/50
32/32 [==============================] - ETA: 0s - loss: 1.7319 - acc: 0.3965
Epoch 9: val_loss improved from 1.72532 to 1.65652, saving model to models/model2_nobatchnorm
INFO:tensorflow:Assets written to: models/model2_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model2_nobatchnorm/assets
32/32 [==============================] - 11s 357ms/step - loss: 1.7319 - acc: 0.3965 - val_loss: 1.6565 - val_a
cc: 0.3912
Epoch 10/50
32/32 [==============================] - ETA: 0s - loss: 1.6383 - acc: 0.4619
Epoch 10: val_loss improved from 1.65652 to 1.58150, saving model to models/model2_nobatchnorm
INFO:tensorflow:Assets written to: models/model2_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model2_nobatchnorm/assets
32/32 [==============================] - 12s 374ms/step - loss: 1.6383 - acc: 0.4619 - val_loss: 1.5815 - val_a
cc: 0.4906
Epoch 11/50
32/32 [==============================] - ETA: 0s - loss: 1.5435 - acc: 0.4824
Epoch 11: val_loss improved from 1.58150 to 1.50213, saving model to models/model2_nobatchnorm
INFO:tensorflow:Assets written to: models/model2_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model2_nobatchnorm/assets
32/32 [==============================] - 11s 350ms/step - loss: 1.5435 - acc: 0.4824 - val_loss: 1.5021 - val_a
cc: 0.4791
Epoch 12/50
32/32 [==============================] - ETA: 0s - loss: 1.5170 - acc: 0.4921
Epoch 12: val_loss improved from 1.50213 to 1.45472, saving model to models/model2_nobatchnorm
INFO:tensorflow:Assets written to: models/model2_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model2_nobatchnorm/assets
32/32 [==============================] - 12s 371ms/step - loss: 1.5170 - acc: 0.4921 - val_loss: 1.4547 - val_a
cc: 0.5481
Epoch 13/50
32/32 [==============================] - ETA: 0s - loss: 1.4575 - acc: 0.5215
Epoch 13: val_loss improved from 1.45472 to 1.38676, saving model to models/model2_nobatchnorm
INFO:tensorflow:Assets written to: models/model2_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model2_nobatchnorm/assets
32/32 [==============================] - 12s 362ms/step - loss: 1.4575 - acc: 0.5215 - val_loss: 1.3868 - val_a
cc: 0.5324
Epoch 14/50
32/32 [==============================] - ETA: 0s - loss: 1.3642 - acc: 0.5117
Epoch 14: val_loss improved from 1.38676 to 1.38558, saving model to models/model2_nobatchnorm
INFO:tensorflow:Assets written to: models/model2_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model2_nobatchnorm/assets
32/32 [==============================] - 12s 385ms/step - loss: 1.3642 - acc: 0.5117 - val_loss: 1.3856 - val_a
cc: 0.5523
Epoch 15/50
32/32 [==============================] - ETA: 0s - loss: 1.4571 - acc: 0.5218
Epoch 15: val_loss improved from 1.38558 to 1.33885, saving model to models/model2_nobatchnorm
INFO:tensorflow:Assets written to: models/model2_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model2_nobatchnorm/assets
32/32 [==============================] - 10s 331ms/step - loss: 1.4571 - acc: 0.5218 - val_loss: 1.3389 - val_a
cc: 0.5649
Epoch 16/50
32/32 [==============================] - ETA: 0s - loss: 1.3415 - acc: 0.5381
Epoch 16: val_loss improved from 1.33885 to 1.27741, saving model to models/model2_nobatchnorm
INFO:tensorflow:Assets written to: models/model2_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model2_nobatchnorm/assets
32/32 [==============================] - 12s 382ms/step - loss: 1.3415 - acc: 0.5381 - val_loss: 1.2774 - val_a
cc: 0.5701
Epoch 17/50
32/32 [==============================] - ETA: 0s - loss: 1.3034 - acc: 0.5684
Epoch 17: val_loss improved from 1.27741 to 1.19331, saving model to models/model2_nobatchnorm
INFO:tensorflow:Assets written to: models/model2_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model2_nobatchnorm/assets
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32/32 [==============================] - 12s 393ms/step - loss: 1.3034 - acc: 0.5684 - val_loss: 1.1933 - val_a
cc: 0.6140
Epoch 18/50
32/32 [==============================] - ETA: 0s - loss: 1.2821 - acc: 0.5723
Epoch 18: val_loss did not improve from 1.19331
32/32 [==============================] - 10s 327ms/step - loss: 1.2821 - acc: 0.5723 - val_loss: 1.2608 - val_a
cc: 0.5785
Epoch 19/50
32/32 [==============================] - ETA: 0s - loss: 1.2548 - acc: 0.5822
Epoch 19: val_loss did not improve from 1.19331
32/32 [==============================] - 9s 272ms/step - loss: 1.2548 - acc: 0.5822 - val_loss: 1.2355 - val_ac
c: 0.5774
Epoch 20/50
32/32 [==============================] - ETA: 0s - loss: 1.2346 - acc: 0.5918
Epoch 20: val_loss improved from 1.19331 to 1.14081, saving model to models/model2_nobatchnorm
INFO:tensorflow:Assets written to: models/model2_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model2_nobatchnorm/assets
32/32 [==============================] - 11s 362ms/step - loss: 1.2346 - acc: 0.5918 - val_loss: 1.1408 - val_a
cc: 0.6339
Epoch 21/50
32/32 [==============================] - ETA: 0s - loss: 1.1775 - acc: 0.6113
Epoch 21: val_loss improved from 1.14081 to 1.13441, saving model to models/model2_nobatchnorm
INFO:tensorflow:Assets written to: models/model2_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model2_nobatchnorm/assets
32/32 [==============================] - 12s 375ms/step - loss: 1.1775 - acc: 0.6113 - val_loss: 1.1344 - val_a
cc: 0.6245
Epoch 22/50
32/32 [==============================] - ETA: 0s - loss: 1.1666 - acc: 0.5967
Epoch 22: val_loss did not improve from 1.13441
32/32 [==============================] - 9s 296ms/step - loss: 1.1666 - acc: 0.5967 - val_loss: 1.2059 - val_ac
c: 0.5868
Epoch 23/50
32/32 [==============================] - ETA: 0s - loss: 1.1091 - acc: 0.6079
Epoch 23: val_loss did not improve from 1.13441
32/32 [==============================] - 11s 337ms/step - loss: 1.1091 - acc: 0.6079 - val_loss: 1.1829 - val_a
cc: 0.6046
Epoch 24/50
32/32 [==============================] - ETA: 0s - loss: 1.0908 - acc: 0.6348
Epoch 24: val_loss improved from 1.13441 to 1.11488, saving model to models/model2_nobatchnorm
INFO:tensorflow:Assets written to: models/model2_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model2_nobatchnorm/assets
32/32 [==============================] - 12s 387ms/step - loss: 1.0908 - acc: 0.6348 - val_loss: 1.1149 - val_a
cc: 0.6172
Epoch 25/50
32/32 [==============================] - ETA: 0s - loss: 1.1253 - acc: 0.6074
Epoch 25: val_loss did not improve from 1.11488
32/32 [==============================] - 10s 308ms/step - loss: 1.1253 - acc: 0.6074 - val_loss: 1.2634 - val_a
cc: 0.5492
Epoch 26/50
32/32 [==============================] - ETA: 0s - loss: 1.0836 - acc: 0.6455
Epoch 26: val_loss improved from 1.11488 to 1.09459, saving model to models/model2_nobatchnorm
INFO:tensorflow:Assets written to: models/model2_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model2_nobatchnorm/assets
32/32 [==============================] - 10s 334ms/step - loss: 1.0836 - acc: 0.6455 - val_loss: 1.0946 - val_a
cc: 0.6349
Epoch 27/50
32/32 [==============================] - ETA: 0s - loss: 0.9800 - acc: 0.6822
Epoch 27: val_loss did not improve from 1.09459
32/32 [==============================] - 13s 409ms/step - loss: 0.9800 - acc: 0.6822 - val_loss: 1.0979 - val_a
cc: 0.6213
Epoch 28/50
32/32 [==============================] - ETA: 0s - loss: 1.0715 - acc: 0.6523
Epoch 28: val_loss did not improve from 1.09459
32/32 [==============================] - 9s 297ms/step - loss: 1.0715 - acc: 0.6523 - val_loss: 1.1138 - val_ac
c: 0.6370
Epoch 29/50
32/32 [==============================] - ETA: 0s - loss: 1.1322 - acc: 0.6309
Epoch 29: val_loss did not improve from 1.09459
32/32 [==============================] - 9s 290ms/step - loss: 1.1322 - acc: 0.6309 - val_loss: 1.1923 - val_ac
c: 0.5994
Epoch 30/50
32/32 [==============================] - ETA: 0s - loss: 1.0368 - acc: 0.6663
Epoch 30: val_loss did not improve from 1.09459
32/32 [==============================] - 9s 285ms/step - loss: 1.0368 - acc: 0.6663 - val_loss: 1.1390 - val_ac
c: 0.6192
Epoch 31/50
32/32 [==============================] - ETA: 0s - loss: 0.9360 - acc: 0.6982
Epoch 31: val_loss did not improve from 1.09459
32/32 [==============================] - 9s 292ms/step - loss: 0.9360 - acc: 0.6982 - val_loss: 1.1421 - val_ac
c: 0.6433
Epoch 32/50
32/32 [==============================] - ETA: 0s - loss: 0.9685 - acc: 0.6973
Epoch 32: val_loss improved from 1.09459 to 1.03345, saving model to models/model2_nobatchnorm
INFO:tensorflow:Assets written to: models/model2_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model2_nobatchnorm/assets
```

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32/32 [==============================] - 13s 409ms/step - loss: 0.9685 - acc: 0.6973 - val_loss: 1.0335 - val_a
cc: 0.6579
Epoch 33/50
32/32 [==============================] - ETA: 0s - loss: 0.9271 - acc: 0.7012
Epoch 33: val_loss improved from 1.03345 to 1.01040, saving model to models/model2_nobatchnorm
INFO:tensorflow:Assets written to: models/model2_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model2_nobatchnorm/assets
32/32 [==============================] - 12s 373ms/step - loss: 0.9271 - acc: 0.7012 - val_loss: 1.0104 - val_a
cc: 0.6841
Epoch 34/50
32/32 [==============================] - ETA: 0s - loss: 0.9501 - acc: 0.6792
Epoch 34: val_loss did not improve from 1.01040
32/32 [==============================] - 9s 279ms/step - loss: 0.9501 - acc: 0.6792 - val_loss: 1.0482 - val_ac
c: 0.6454
Epoch 35/50
32/32 [==============================] - ETA: 0s - loss: 0.9857 - acc: 0.6836
Epoch 35: val_loss did not improve from 1.01040
32/32 [==============================] - 9s 297ms/step - loss: 0.9857 - acc: 0.6836 - val_loss: 1.0220 - val_ac
c: 0.6705
Epoch 36/50
32/32 [==============================] - ETA: 0s - loss: 0.8696 - acc: 0.7139
Epoch 36: val_loss did not improve from 1.01040
32/32 [==============================] - 10s 318ms/step - loss: 0.8696 - acc: 0.7139 - val_loss: 1.1058 - val_a
cc: 0.6318
Epoch 37/50
32/32 [==============================] - ETA: 0s - loss: 0.9179 - acc: 0.7041
Epoch 37: val_loss did not improve from 1.01040
32/32 [==============================] - 7s 234ms/step - loss: 0.9179 - acc: 0.7041 - val_loss: 1.0759 - val_ac
c: 0.6255
Epoch 38/50
32/32 [==============================] - ETA: 0s - loss: 0.8340 - acc: 0.7119
Epoch 38: val_loss did not improve from 1.01040
32/32 [==============================] - 9s 298ms/step - loss: 0.8340 - acc: 0.7119 - val_loss: 1.0240 - val_ac
c: 0.6444
Epoch 39/50
32/32 [==============================] - ETA: 0s - loss: 0.8947 - acc: 0.7109
Epoch 39: val_loss improved from 1.01040 to 1.00646, saving model to models/model2_nobatchnorm
INFO:tensorflow:Assets written to: models/model2_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model2_nobatchnorm/assets
32/32 [==============================] - 11s 352ms/step - loss: 0.8947 - acc: 0.7109 - val_loss: 1.0065 - val_a
cc: 0.6789
Epoch 40/50
32/32 [==============================] - ETA: 0s - loss: 0.7536 - acc: 0.7432
Epoch 40: val_loss did not improve from 1.00646
32/32 [==============================] - 10s 298ms/step - loss: 0.7536 - acc: 0.7432 - val_loss: 1.0395 - val_a
cc: 0.6674
Epoch 41/50
32/32 [==============================] - ETA: 0s - loss: 0.8537 - acc: 0.7366
Epoch 41: val_loss did not improve from 1.00646
32/32 [==============================] - 8s 240ms/step - loss: 0.8537 - acc: 0.7366 - val_loss: 1.0283 - val_ac
c: 0.6726
Epoch 42/50
32/32 [==============================] - ETA: 0s - loss: 0.7973 - acc: 0.7363
Epoch 42: val_loss did not improve from 1.00646
32/32 [==============================] - 9s 275ms/step - loss: 0.7973 - acc: 0.7363 - val_loss: 1.0151 - val_ac
c: 0.6768
Epoch 43/50
32/32 [==============================] - ETA: 0s - loss: 0.8051 - acc: 0.7559
Epoch 43: val_loss improved from 1.00646 to 1.00357, saving model to models/model2_nobatchnorm
INFO:tensorflow:Assets written to: models/model2_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model2_nobatchnorm/assets
32/32 [==============================] - 12s 379ms/step - loss: 0.8051 - acc: 0.7559 - val_loss: 1.0036 - val_a
cc: 0.6799
Epoch 44/50
32/32 [==============================] - ETA: 0s - loss: 0.7049 - acc: 0.7744
Epoch 44: val_loss did not improve from 1.00357
32/32 [==============================] - 9s 296ms/step - loss: 0.7049 - acc: 0.7744 - val_loss: 1.0151 - val_ac
c: 0.6684
Epoch 45/50
32/32 [==============================] - ETA: 0s - loss: 0.7391 - acc: 0.7535
Epoch 45: val_loss improved from 1.00357 to 0.97444, saving model to models/model2_nobatchnorm
INFO:tensorflow:Assets written to: models/model2_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model2_nobatchnorm/assets
32/32 [==============================] - 11s 355ms/step - loss: 0.7391 - acc: 0.7535 - val_loss: 0.9744 - val_a
cc: 0.6935
Epoch 46/50
32/32 [==============================] - ETA: 0s - loss: 0.7178 - acc: 0.7529
Epoch 46: val_loss improved from 0.97444 to 0.95030, saving model to models/model2_nobatchnorm
INFO:tensorflow:Assets written to: models/model2_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model2_nobatchnorm/assets
32/32 [==============================] - 11s 356ms/step - loss: 0.7178 - acc: 0.7529 - val_loss: 0.9503 - val_a
cc: 0.7029
Epoch 47/50
32/32 [==============================] - ETA: 0s - loss: 0.7385 - acc: 0.7578
Epoch 47: val_loss improved from 0.95030 to 0.93477, saving model to models/model2_nobatchnorm
INFO:tensorflow:Assets written to: models/model2_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model2_nobatchnorm/assets
```

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32/32 [==============================] - 11s 348ms/step - loss: 0.7385 - acc: 0.7578 - val_loss: 0.9348 - val_a
cc: 0.7061
Epoch 48/50
32/32 [==============================] - ETA: 0s - loss: 0.7428 - acc: 0.7744
Epoch 48: val_loss did not improve from 0.93477
32/32 [==============================] - 8s 265ms/step - loss: 0.7428 - acc: 0.7744 - val_loss: 0.9470 - val_ac
c: 0.6946
Epoch 49/50
32/32 [==============================] - ETA: 0s - loss: 0.7172 - acc: 0.7604
Epoch 49: val_loss did not improve from 0.93477
32/32 [==============================] - 9s 274ms/step - loss: 0.7172 - acc: 0.7604 - val_loss: 1.0310 - val_ac
c: 0.6412
Epoch 50/50
32/32 [==============================] - ETA: 0s - loss: 0.6637 - acc: 0.7783
Epoch 50: val_loss did not improve from 0.93477
32/32 [==============================] - 9s 280ms/step - loss: 0.6637 - acc: 0.7783 - val_loss: 1.0084 - val_ac
c: 0.6705
Running Experiment: model3
Model: "sequential_4"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 block1 (Sequential)         (None, 112, 112, 64)      2048

 block2 (Sequential)         (None, 56, 56, 128)       74368

 block3 (Sequential)         (None, 28, 28, 256)       296192

 block4 (Sequential)         (None, 14, 14, 512)       1182208

 top_model_flatten (Flatten  (None, 100352)            0
 )

 top_model_dense_1 (Dense)   (None, 128)               12845184

 top_model_output (Dense)    (None, 12)                1548

=================================================================
Total params: 14401548 (54.94 MB)
Trainable params: 14399628 (54.93 MB)
Non-trainable params: 1920 (7.50 KB)
_________________________________________________________________
None
Epoch 1/50
2023-11-26 19:17:37.620924: E tensorflow/core/grappler/optimizers/meta_optimizer.cc:961] layout failed: INVALID
_ARGUMENT: Size of values 0 does not match size of permutation 4 @ fanin shape insequential_4/block1/dropout_10
/dropout/SelectV2-2-TransposeNHWCToNCHW-LayoutOptimizer
 6/32 [====>.........................] - ETA: 2s - loss: 7.0151 - acc: 0.1094WARNING:tensorflow:Callback method
`on_train_batch_end` is slow compared to the batch time (batch time: 0.0375s vs `on_train_batch_end` time: 0.05
39s). Check your callbacks.
WARNING:tensorflow:Callback method `on_train_batch_end` is slow compared to the batch time (batch time: 0.0375s
vs `on_train_batch_end` time: 0.0539s). Check your callbacks.
32/32 [==============================] - ETA: 0s - loss: 4.0761 - acc: 0.1533
Epoch 1: val_loss improved from inf to 11.34777, saving model to models/model3
INFO:tensorflow:Assets written to: models/model3/assets
INFO:tensorflow:Assets written to: models/model3/assets
```

```
32/32 [==============================] - 14s 348ms/step - loss: 4.0761 - acc: 0.1533 - val_loss: 11.3478 - val_
acc: 0.1370
Epoch 2/50
32/32 [==============================] - ETA: 0s - loss: 2.2385 - acc: 0.1885
Epoch 2: val_loss did not improve from 11.34777
32/32 [==============================] - 10s 306ms/step - loss: 2.2385 - acc: 0.1885 - val_loss: 19.6838 - val_
acc: 0.1370
Epoch 3/50
32/32 [==============================] - ETA: 0s - loss: 2.0913 - acc: 0.2412
Epoch 3: val_loss did not improve from 11.34777
32/32 [==============================] - 10s 319ms/step - loss: 2.0913 - acc: 0.2412 - val_loss: 22.0937 - val_
acc: 0.1370
Epoch 4/50
32/32 [==============================] - ETA: 0s - loss: 1.9802 - acc: 0.2901
Epoch 4: val_loss did not improve from 11.34777
32/32 [==============================] - 8s 261ms/step - loss: 1.9802 - acc: 0.2901 - val_loss: 26.7574 - val_a
cc: 0.1370
Epoch 5/50
32/32 [==============================] - ETA: 0s - loss: 1.7681 - acc: 0.3779
Epoch 5: val_loss did not improve from 11.34777
32/32 [==============================] - 10s 311ms/step - loss: 1.7681 - acc: 0.3779 - val_loss: 29.8587 - val_
acc: 0.1370
Epoch 6/50
32/32 [==============================] - ETA: 0s - loss: 1.5902 - acc: 0.4443
Epoch 6: val_loss did not improve from 11.34777
32/32 [==============================] - 9s 298ms/step - loss: 1.5902 - acc: 0.4443 - val_loss: 26.7227 - val_a
cc: 0.1370
Epoch 7/50
32/32 [==============================] - ETA: 0s - loss: 1.4873 - acc: 0.4834
Epoch 7: val_loss did not improve from 11.34777
32/32 [==============================] - 8s 264ms/step - loss: 1.4873 - acc: 0.4834 - val_loss: 25.7669 - val_a

cc: 0.1370
Epoch 8/50
32/32 [==============================] - ETA: 0s - loss: 1.3746 - acc: 0.5228
Epoch 8: val_loss did not improve from 11.34777
32/32 [==============================] - 9s 272ms/step - loss: 1.3746 - acc: 0.5228 - val_loss: 24.6361 - val_a
cc: 0.1370
Epoch 9/50
32/32 [==============================] - ETA: 0s - loss: 1.2674 - acc: 0.5703
Epoch 9: val_loss did not improve from 11.34777
32/32 [==============================] - 9s 291ms/step - loss: 1.2674 - acc: 0.5703 - val_loss: 21.9858 - val_a
cc: 0.1370
Epoch 10/50
32/32 [==============================] - ETA: 0s - loss: 1.3731 - acc: 0.5605
Epoch 10: val_loss did not improve from 11.34777
32/32 [==============================] - 9s 281ms/step - loss: 1.3731 - acc: 0.5605 - val_loss: 11.6116 - val_a
cc: 0.1454
Epoch 11/50
32/32 [==============================] - ETA: 0s - loss: 1.2936 - acc: 0.5381
Epoch 11: val_loss improved from 11.34777 to 6.09095, saving model to models/model3
INFO:tensorflow:Assets written to: models/model3/assets
INFO:tensorflow:Assets written to: models/model3/assets
32/32 [==============================] - 12s 377ms/step - loss: 1.2936 - acc: 0.5381 - val_loss: 6.0909 - val_a
cc: 0.1789
Epoch 12/50
32/32 [==============================] - ETA: 0s - loss: 1.0585 - acc: 0.6426
Epoch 12: val_loss improved from 6.09095 to 5.28668, saving model to models/model3
INFO:tensorflow:Assets written to: models/model3/assets
INFO:tensorflow:Assets written to: models/model3/assets
32/32 [==============================] - 12s 371ms/step - loss: 1.0585 - acc: 0.6426 - val_loss: 5.2867 - val_a
cc: 0.1946
Epoch 13/50
32/32 [==============================] - ETA: 0s - loss: 1.0073 - acc: 0.6494
Epoch 13: val_loss improved from 5.28668 to 3.72143, saving model to models/model3
INFO:tensorflow:Assets written to: models/model3/assets
INFO:tensorflow:Assets written to: models/model3/assets
32/32 [==============================] - 12s 387ms/step - loss: 1.0073 - acc: 0.6494 - val_loss: 3.7214 - val_a
cc: 0.2782
Epoch 14/50
32/32 [==============================] - ETA: 0s - loss: 1.0296 - acc: 0.6416
Epoch 14: val_loss improved from 3.72143 to 3.09427, saving model to models/model3
INFO:tensorflow:Assets written to: models/model3/assets
INFO:tensorflow:Assets written to: models/model3/assets
32/32 [==============================] - 11s 361ms/step - loss: 1.0296 - acc: 0.6416 - val_loss: 3.0943 - val_a
cc: 0.2709
Epoch 15/50
32/32 [==============================] - ETA: 0s - loss: 1.0651 - acc: 0.6356
Epoch 15: val_loss did not improve from 3.09427
32/32 [==============================] - 9s 270ms/step - loss: 1.0651 - acc: 0.6356 - val_loss: 3.0979 - val_ac
c: 0.3787
Epoch 16/50
32/32 [==============================] - ETA: 0s - loss: 0.9386 - acc: 0.6768
Epoch 16: val_loss improved from 3.09427 to 2.09064, saving model to models/model3
INFO:tensorflow:Assets written to: models/model3/assets
INFO:tensorflow:Assets written to: models/model3/assets
```

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32/32 [==============================] - 12s 389ms/step - loss: 0.9386 - acc: 0.6768 - val_loss: 2.0906 - val_a
cc: 0.4257
Epoch 17/50
32/32 [==============================] - ETA: 0s - loss: 0.7969 - acc: 0.7207
Epoch 17: val_loss improved from 2.09064 to 1.90015, saving model to models/model3
INFO:tensorflow:Assets written to: models/model3/assets
INFO:tensorflow:Assets written to: models/model3/assets
32/32 [==============================] - 11s 351ms/step - loss: 0.7969 - acc: 0.7207 - val_loss: 1.9001 - val_a
cc: 0.4215
Epoch 18/50
32/32 [==============================] - ETA: 0s - loss: 0.8099 - acc: 0.7305
Epoch 18: val_loss improved from 1.90015 to 1.65517, saving model to models/model3
INFO:tensorflow:Assets written to: models/model3/assets
INFO:tensorflow:Assets written to: models/model3/assets
32/32 [==============================] - 11s 338ms/step - loss: 0.8099 - acc: 0.7305 - val_loss: 1.6552 - val_a
cc: 0.4770
Epoch 19/50
32/32 [==============================] - ETA: 0s - loss: 0.9600 - acc: 0.6832
Epoch 19: val_loss did not improve from 1.65517
32/32 [==============================] - 9s 275ms/step - loss: 0.9600 - acc: 0.6832 - val_loss: 1.6607 - val_ac
c: 0.5230
Epoch 20/50
32/32 [==============================] - ETA: 0s - loss: 0.8046 - acc: 0.7383
Epoch 20: val_loss improved from 1.65517 to 1.32886, saving model to models/model3
INFO:tensorflow:Assets written to: models/model3/assets
INFO:tensorflow:Assets written to: models/model3/assets
32/32 [==============================] - 11s 347ms/step - loss: 0.8046 - acc: 0.7383 - val_loss: 1.3289 - val_a
cc: 0.5921
Epoch 21/50
32/32 [==============================] - ETA: 0s - loss: 0.6893 - acc: 0.7578
Epoch 21: val_loss improved from 1.32886 to 0.97684, saving model to models/model3
INFO:tensorflow:Assets written to: models/model3/assets
INFO:tensorflow:Assets written to: models/model3/assets
32/32 [==============================] - 12s 379ms/step - loss: 0.6893 - acc: 0.7578 - val_loss: 0.9768 - val_a
cc: 0.6663
Epoch 22/50
32/32 [==============================] - ETA: 0s - loss: 0.7622 - acc: 0.7490
Epoch 22: val_loss improved from 0.97684 to 0.86301, saving model to models/model3
INFO:tensorflow:Assets written to: models/model3/assets
INFO:tensorflow:Assets written to: models/model3/assets
32/32 [==============================] - 11s 344ms/step - loss: 0.7622 - acc: 0.7490 - val_loss: 0.8630 - val_a
cc: 0.7186
Epoch 23/50
32/32 [==============================] - ETA: 0s - loss: 0.7323 - acc: 0.7455
Epoch 23: val_loss did not improve from 0.86301
32/32 [==============================] - 10s 312ms/step - loss: 0.7323 - acc: 0.7455 - val_loss: 0.8913 - val_a
cc: 0.7238
Epoch 24/50
32/32 [==============================] - ETA: 0s - loss: 0.7280 - acc: 0.7520
Epoch 24: val_loss improved from 0.86301 to 0.81027, saving model to models/model3
INFO:tensorflow:Assets written to: models/model3/assets
INFO:tensorflow:Assets written to: models/model3/assets
32/32 [==============================] - 11s 352ms/step - loss: 0.7280 - acc: 0.7520 - val_loss: 0.8103 - val_a
cc: 0.7479
Epoch 25/50
32/32 [==============================] - ETA: 0s - loss: 0.6319 - acc: 0.7676
Epoch 25: val_loss did not improve from 0.81027
32/32 [==============================] - 10s 298ms/step - loss: 0.6319 - acc: 0.7676 - val_loss: 0.8207 - val_a
cc: 0.7270
Epoch 26/50
32/32 [==============================] - ETA: 0s - loss: 0.6516 - acc: 0.7842
Epoch 26: val_loss improved from 0.81027 to 0.73432, saving model to models/model3
INFO:tensorflow:Assets written to: models/model3/assets
INFO:tensorflow:Assets written to: models/model3/assets
32/32 [==============================] - 10s 324ms/step - loss: 0.6516 - acc: 0.7842 - val_loss: 0.7343 - val_a
cc: 0.7469
Epoch 27/50
32/32 [==============================] - ETA: 0s - loss: 0.6813 - acc: 0.7663
Epoch 27: val_loss did not improve from 0.73432
32/32 [==============================] - 10s 320ms/step - loss: 0.6813 - acc: 0.7663 - val_loss: 0.7682 - val_a
cc: 0.7458
Epoch 28/50
32/32 [==============================] - ETA: 0s - loss: 0.6028 - acc: 0.8105
Epoch 28: val_loss improved from 0.73432 to 0.64487, saving model to models/model3
INFO:tensorflow:Assets written to: models/model3/assets
INFO:tensorflow:Assets written to: models/model3/assets
```

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32/32 [==============================] - 10s 329ms/step - loss: 0.6028 - acc: 0.8105 - val_loss: 0.6449 - val_a
cc: 0.7793
Epoch 29/50
32/32 [==============================] - ETA: 0s - loss: 0.5471 - acc: 0.8115
Epoch 29: val_loss did not improve from 0.64487
32/32 [==============================] - 10s 307ms/step - loss: 0.5471 - acc: 0.8115 - val_loss: 0.7808 - val_a
cc: 0.7584
Epoch 30/50
32/32 [==============================] - ETA: 0s - loss: 0.7108 - acc: 0.7574
Epoch 30: val_loss did not improve from 0.64487
32/32 [==============================] - 9s 297ms/step - loss: 0.7108 - acc: 0.7574 - val_loss: 0.7747 - val_ac
c: 0.7542
Epoch 31/50
32/32 [==============================] - ETA: 0s - loss: 0.5196 - acc: 0.8125
Epoch 31: val_loss improved from 0.64487 to 0.64376, saving model to models/model3
INFO:tensorflow:Assets written to: models/model3/assets
INFO:tensorflow:Assets written to: models/model3/assets
32/32 [==============================] - 13s 407ms/step - loss: 0.5196 - acc: 0.8125 - val_loss: 0.6438 - val_a
cc: 0.7929
Epoch 32/50
32/32 [==============================] - ETA: 0s - loss: 0.5361 - acc: 0.8145
Epoch 32: val_loss did not improve from 0.64376
32/32 [==============================] - 9s 288ms/step - loss: 0.5361 - acc: 0.8145 - val_loss: 0.6673 - val_ac
c: 0.7824
Epoch 33/50
32/32 [==============================] - ETA: 0s - loss: 0.5827 - acc: 0.8105
Epoch 33: val_loss did not improve from 0.64376
32/32 [==============================] - 10s 305ms/step - loss: 0.5827 - acc: 0.8105 - val_loss: 0.7436 - val_a
cc: 0.7615
Epoch 34/50
32/32 [==============================] - ETA: 0s - loss: 0.5849 - acc: 0.7931
Epoch 34: val_loss did not improve from 0.64376
32/32 [==============================] - 9s 296ms/step - loss: 0.5849 - acc: 0.7931 - val_loss: 0.8846 - val_ac
c: 0.7333
Epoch 35/50
32/32 [==============================] - ETA: 0s - loss: 0.5140 - acc: 0.8271
Epoch 35: val_loss did not improve from 0.64376
32/32 [==============================] - 10s 319ms/step - loss: 0.5140 - acc: 0.8271 - val_loss: 0.8938 - val_a
cc: 0.7228
Epoch 36/50
32/32 [==============================] - ETA: 0s - loss: 0.4562 - acc: 0.8545
Epoch 36: val_loss did not improve from 0.64376
32/32 [==============================] - 10s 302ms/step - loss: 0.4562 - acc: 0.8545 - val_loss: 0.7480 - val_a
cc: 0.7699
Epoch 37/50
32/32 [==============================] - ETA: 0s - loss: 0.4877 - acc: 0.8389
Epoch 37: val_loss did not improve from 0.64376
32/32 [==============================] - 9s 271ms/step - loss: 0.4877 - acc: 0.8389 - val_loss: 0.8084 - val_ac
c: 0.7573
Epoch 38/50
32/32 [==============================] - ETA: 0s - loss: 0.4100 - acc: 0.8505
Epoch 38: val_loss improved from 0.64376 to 0.64312, saving model to models/model3
INFO:tensorflow:Assets written to: models/model3/assets
INFO:tensorflow:Assets written to: models/model3/assets
32/32 [==============================] - 13s 401ms/step - loss: 0.4100 - acc: 0.8505 - val_loss: 0.6431 - val_a
cc: 0.7845
Epoch 39/50
32/32 [==============================] - ETA: 0s - loss: 0.4250 - acc: 0.8467
Epoch 39: val_loss did not improve from 0.64312
32/32 [==============================] - 10s 316ms/step - loss: 0.4250 - acc: 0.8467 - val_loss: 0.6897 - val_a
cc: 0.7897
Epoch 40/50
32/32 [==============================] - ETA: 0s - loss: 0.5067 - acc: 0.8369
Epoch 40: val_loss improved from 0.64312 to 0.51126, saving model to models/model3
INFO:tensorflow:Assets written to: models/model3/assets
INFO:tensorflow:Assets written to: models/model3/assets
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32/32 [==============================] - 12s 394ms/step - loss: 0.5067 - acc: 0.8369 - val_loss: 0.5113 - val_a
cc: 0.8190
Epoch 41/50
32/32 [==============================] - ETA: 0s - loss: 0.4157 - acc: 0.8416
Epoch 41: val_loss did not improve from 0.51126
32/32 [==============================] - 10s 315ms/step - loss: 0.4157 - acc: 0.8416 - val_loss: 0.6337 - val_a
cc: 0.8002
Epoch 42/50
32/32 [==============================] - ETA: 0s - loss: 0.3793 - acc: 0.8613
Epoch 42: val_loss did not improve from 0.51126
32/32 [==============================] - 10s 303ms/step - loss: 0.3793 - acc: 0.8613 - val_loss: 0.6934 - val_a
cc: 0.7835
Epoch 43/50
32/32 [==============================] - ETA: 0s - loss: 0.4491 - acc: 0.8604
Epoch 43: val_loss did not improve from 0.51126
32/32 [==============================] - 10s 312ms/step - loss: 0.4491 - acc: 0.8604 - val_loss: 0.6739 - val_a
cc: 0.7981
Epoch 44/50
32/32 [==============================] - ETA: 0s - loss: 0.4175 - acc: 0.8594
Epoch 44: val_loss did not improve from 0.51126
32/32 [==============================] - 10s 310ms/step - loss: 0.4175 - acc: 0.8594 - val_loss: 0.8770 - val_a
cc: 0.7510
Epoch 45/50
32/32 [==============================] - ETA: 0s - loss: 0.3934 - acc: 0.8525
Epoch 45: val_loss did not improve from 0.51126
32/32 [==============================] - 10s 332ms/step - loss: 0.3934 - acc: 0.8525 - val_loss: 0.6475 - val_a
cc: 0.7939
Epoch 46/50
32/32 [==============================] - ETA: 0s - loss: 0.4301 - acc: 0.8545
Epoch 46: val_loss did not improve from 0.51126
32/32 [==============================] - 10s 307ms/step - loss: 0.4301 - acc: 0.8545 - val_loss: 0.6166 - val_a
cc: 0.8159
Epoch 47/50
32/32 [==============================] - ETA: 0s - loss: 0.3977 - acc: 0.8486
Epoch 47: val_loss did not improve from 0.51126
32/32 [==============================] - 9s 291ms/step - loss: 0.3977 - acc: 0.8486 - val_loss: 0.7644 - val_ac
c: 0.7573
Epoch 48/50
32/32 [==============================] - ETA: 0s - loss: 0.3908 - acc: 0.8789
Epoch 48: val_loss improved from 0.51126 to 0.50210, saving model to models/model3
INFO:tensorflow:Assets written to: models/model3/assets
INFO:tensorflow:Assets written to: models/model3/assets
32/32 [==============================] - 11s 358ms/step - loss: 0.3908 - acc: 0.8789 - val_loss: 0.5021 - val_a
cc: 0.8358
Epoch 49/50
32/32 [==============================] - ETA: 0s - loss: 0.4183 - acc: 0.8653
Epoch 49: val_loss did not improve from 0.50210
32/32 [==============================] - 9s 290ms/step - loss: 0.4183 - acc: 0.8653 - val_loss: 0.5212 - val_ac
c: 0.8379
Epoch 50/50
32/32 [==============================] - ETA: 0s - loss: 0.3898 - acc: 0.8818
Epoch 50: val_loss did not improve from 0.50210
32/32 [==============================] - 9s 285ms/step - loss: 0.3898 - acc: 0.8818 - val_loss: 0.6343 - val_ac
c: 0.8159
Running Experiment: model3_nobatchnorm
Model: "sequential_5"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 block1 (Sequential)         (None, 112, 112, 64)      1792

 block2 (Sequential)         (None, 56, 56, 128)       73856

 block3 (Sequential)         (None, 28, 28, 256)       295168

 block4 (Sequential)         (None, 14, 14, 512)       1180160

 top_model_flatten (Flatten  (None, 100352)            0
 )

 top_model_dense_1 (Dense)   (None, 128)               12845184

 top_model_output (Dense)    (None, 12)                1548

=================================================================
Total params: 14397708 (54.92 MB)
Trainable params: 14397708 (54.92 MB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
None
Epoch 1/50
2023-11-26 19:26:09.154955: E tensorflow/core/grappler/optimizers/meta_optimizer.cc:961] layout failed: INVALID
_ARGUMENT: Size of values 0 does not match size of permutation 4 @ fanin shape insequential_5/block1/dropout_14
/dropout/SelectV2-2-TransposeNHWCToNCHW-LayoutOptimizer
 6/32 [====>.........................] - ETA: 3s - loss: 2.5770 - acc: 0.0833WARNING:tensorflow:Callback method
`on_train_batch_end` is slow compared to the batch time (batch time: 0.0415s vs `on_train_batch_end` time: 0.06
31s). Check your callbacks.
```

```
WARNING:tensorflow:Callback method `on_train_batch_end` is slow compared to the batch time (batch time: 0.0415s vs `on_train_batch_end` time: 0.0631s). Check your callbacks.
32/32 [==============================] - ETA: 0s - loss: 2.5124 - acc: 0.0635
Epoch 1: val_loss improved from inf to 2.48293, saving model to models/model3_nobatchnorm
INFO:tensorflow:Assets written to: models/model3_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model3_nobatchnorm/assets
32/32 [==============================] - 12s 327ms/step - loss: 2.5124 - acc: 0.0635 - val_loss: 2.4829 - val_acc: 0.0554
Epoch 2/50
32/32 [==============================] - ETA: 0s - loss: 2.4596 - acc: 0.0771
Epoch 2: val_loss improved from 2.48293 to 2.45301, saving model to models/model3_nobatchnorm
INFO:tensorflow:Assets written to: models/model3_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model3_nobatchnorm/assets
32/32 [==============================] - 11s 345ms/step - loss: 2.4596 - acc: 0.0771 - val_loss: 2.4530 - val_acc: 0.0826
Epoch 3/50
32/32 [==============================] - ETA: 0s - loss: 2.3540 - acc: 0.1191
Epoch 3: val_loss improved from 2.45301 to 2.24443, saving model to models/model3_nobatchnorm
INFO:tensorflow:Assets written to: models/model3_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model3_nobatchnorm/assets
32/32 [==============================] - 11s 364ms/step - loss: 2.3540 - acc: 0.1191 - val_loss: 2.2444 - val_acc: 0.2092
Epoch 4/50
32/32 [==============================] - ETA: 0s - loss: 2.0726 - acc: 0.2109
Epoch 4: val_loss improved from 2.24443 to 2.01219, saving model to models/model3_nobatchnorm
INFO:tensorflow:Assets written to: models/model3_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model3_nobatchnorm/assets
32/32 [==============================] - 10s 326ms/step - loss: 2.0726 - acc: 0.2109 - val_loss: 2.0122 - val_acc: 0.2678
Epoch 5/50
32/32 [==============================] - ETA: 0s - loss: 1.9160 - acc: 0.2451
Epoch 5: val_loss improved from 2.01219 to 1.86625, saving model to models/model3_nobatchnorm
INFO:tensorflow:Assets written to: models/model3_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model3_nobatchnorm/assets
32/32 [==============================] - 10s 330ms/step - loss: 1.9160 - acc: 0.2451 - val_loss: 1.8662 - val_acc: 0.3065
Epoch 6/50
32/32 [==============================] - ETA: 0s - loss: 1.8128 - acc: 0.2852
Epoch 6: val_loss improved from 1.86625 to 1.80241, saving model to models/model3_nobatchnorm
INFO:tensorflow:Assets written to: models/model3_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model3_nobatchnorm/assets
32/32 [==============================] - 12s 384ms/step - loss: 1.8128 - acc: 0.2852 - val_loss: 1.8024 - val_acc: 0.3232
Epoch 7/50
32/32 [==============================] - ETA: 0s - loss: 1.7701 - acc: 0.3125
Epoch 7: val_loss improved from 1.80241 to 1.78116, saving model to models/model3_nobatchnorm
INFO:tensorflow:Assets written to: models/model3_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model3_nobatchnorm/assets
32/32 [==============================] - 12s 394ms/step - loss: 1.7701 - acc: 0.3125 - val_loss: 1.7812 - val_acc: 0.2782
Epoch 8/50
32/32 [==============================] - ETA: 0s - loss: 1.7667 - acc: 0.3297
Epoch 8: val_loss improved from 1.78116 to 1.69187, saving model to models/model3_nobatchnorm
INFO:tensorflow:Assets written to: models/model3_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model3_nobatchnorm/assets
32/32 [==============================] - 11s 363ms/step - loss: 1.7667 - acc: 0.3297 - val_loss: 1.6919 - val_acc: 0.3169
Epoch 9/50
32/32 [==============================] - ETA: 0s - loss: 1.6507 - acc: 0.3594
Epoch 9: val_loss improved from 1.69187 to 1.59509, saving model to models/model3_nobatchnorm
INFO:tensorflow:Assets written to: models/model3_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model3_nobatchnorm/assets
32/32 [==============================] - 12s 376ms/step - loss: 1.6507 - acc: 0.3594 - val_loss: 1.5951 - val_acc: 0.4613
Epoch 10/50
32/32 [==============================] - ETA: 0s - loss: 1.5784 - acc: 0.4170
Epoch 10: val_loss improved from 1.59509 to 1.50615, saving model to models/model3_nobatchnorm
INFO:tensorflow:Assets written to: models/model3_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model3_nobatchnorm/assets
32/32 [==============================] - 12s 392ms/step - loss: 1.5784 - acc: 0.4170 - val_loss: 1.5061 - val_acc: 0.4278
Epoch 11/50
32/32 [==============================] - ETA: 0s - loss: 1.5440 - acc: 0.4346
Epoch 11: val_loss improved from 1.50615 to 1.48567, saving model to models/model3_nobatchnorm
INFO:tensorflow:Assets written to: models/model3_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model3_nobatchnorm/assets
32/32 [==============================] - 10s 328ms/step - loss: 1.5440 - acc: 0.4346 - val_loss: 1.4857 - val_acc: 0.5042
Epoch 12/50
32/32 [==============================] - ETA: 0s - loss: 1.4612 - acc: 0.4861
Epoch 12: val_loss improved from 1.48567 to 1.42787, saving model to models/model3_nobatchnorm
INFO:tensorflow:Assets written to: models/model3_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model3_nobatchnorm/assets
```

```
32/32 [==============================] - 11s 352ms/step - loss: 1.4612 - acc: 0.4861 - val_loss: 1.4279 - val_a
cc: 0.5178
Epoch 13/50
32/32 [==============================] - ETA: 0s - loss: 1.3907 - acc: 0.5352
Epoch 13: val_loss improved from 1.42787 to 1.42226, saving model to models/model3_nobatchnorm
INFO:tensorflow:Assets written to: models/model3_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model3_nobatchnorm/assets
32/32 [==============================] - 12s 366ms/step - loss: 1.3907 - acc: 0.5352 - val_loss: 1.4223 - val_a
cc: 0.4812
Epoch 14/50
32/32 [==============================] - ETA: 0s - loss: 1.4972 - acc: 0.4775
Epoch 14: val_loss improved from 1.42226 to 1.36990, saving model to models/model3_nobatchnorm
INFO:tensorflow:Assets written to: models/model3_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model3_nobatchnorm/assets
32/32 [==============================] - 12s 378ms/step - loss: 1.4972 - acc: 0.4775 - val_loss: 1.3699 - val_a
cc: 0.5701
Epoch 15/50
32/32 [==============================] - ETA: 0s - loss: 1.2982 - acc: 0.5446
Epoch 15: val_loss improved from 1.36990 to 1.25837, saving model to models/model3_nobatchnorm
INFO:tensorflow:Assets written to: models/model3_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model3_nobatchnorm/assets
32/32 [==============================] - 11s 346ms/step - loss: 1.2982 - acc: 0.5446 - val_loss: 1.2584 - val_a
cc: 0.5962
Epoch 16/50
32/32 [==============================] - ETA: 0s - loss: 1.2927 - acc: 0.5654
Epoch 16: val_loss did not improve from 1.25837
32/32 [==============================] - 11s 344ms/step - loss: 1.2927 - acc: 0.5654 - val_loss: 1.3389 - val_a
cc: 0.5450
Epoch 17/50
32/32 [==============================] - ETA: 0s - loss: 1.2871 - acc: 0.5498
Epoch 17: val_loss improved from 1.25837 to 1.25134, saving model to models/model3_nobatchnorm
INFO:tensorflow:Assets written to: models/model3_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model3_nobatchnorm/assets
32/32 [==============================] - 10s 310ms/step - loss: 1.2871 - acc: 0.5498 - val_loss: 1.2513 - val_a
cc: 0.5973
Epoch 18/50
32/32 [==============================] - ETA: 0s - loss: 1.2161 - acc: 0.5771
Epoch 18: val_loss improved from 1.25134 to 1.20503, saving model to models/model3_nobatchnorm
INFO:tensorflow:Assets written to: models/model3_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model3_nobatchnorm/assets
32/32 [==============================] - 12s 365ms/step - loss: 1.2161 - acc: 0.5771 - val_loss: 1.2050 - val_a
cc: 0.5952
Epoch 19/50
32/32 [==============================] - ETA: 0s - loss: 1.0758 - acc: 0.6218
Epoch 19: val_loss improved from 1.20503 to 1.09078, saving model to models/model3_nobatchnorm
INFO:tensorflow:Assets written to: models/model3_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model3_nobatchnorm/assets
32/32 [==============================] - 11s 360ms/step - loss: 1.0758 - acc: 0.6218 - val_loss: 1.0908 - val_a
cc: 0.6485
Epoch 20/50
32/32 [==============================] - ETA: 0s - loss: 1.0611 - acc: 0.6494
Epoch 20: val_loss improved from 1.09078 to 1.02915, saving model to models/model3_nobatchnorm
INFO:tensorflow:Assets written to: models/model3_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model3_nobatchnorm/assets
32/32 [==============================] - 11s 354ms/step - loss: 1.0611 - acc: 0.6494 - val_loss: 1.0291 - val_a
cc: 0.6663
Epoch 21/50
32/32 [==============================] - ETA: 0s - loss: 1.0461 - acc: 0.6367
Epoch 21: val_loss improved from 1.02915 to 1.01688, saving model to models/model3_nobatchnorm
INFO:tensorflow:Assets written to: models/model3_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model3_nobatchnorm/assets
32/32 [==============================] - 11s 364ms/step - loss: 1.0461 - acc: 0.6367 - val_loss: 1.0169 - val_a
cc: 0.6820
Epoch 22/50
32/32 [==============================] - ETA: 0s - loss: 1.0695 - acc: 0.6367
Epoch 22: val_loss improved from 1.01688 to 0.98831, saving model to models/model3_nobatchnorm
INFO:tensorflow:Assets written to: models/model3_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model3_nobatchnorm/assets
32/32 [==============================] - 10s 332ms/step - loss: 1.0695 - acc: 0.6367 - val_loss: 0.9883 - val_a
cc: 0.6956
Epoch 23/50
32/32 [==============================] - ETA: 0s - loss: 0.8842 - acc: 0.7228
Epoch 23: val_loss improved from 0.98831 to 0.97229, saving model to models/model3_nobatchnorm
INFO:tensorflow:Assets written to: models/model3_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model3_nobatchnorm/assets
32/32 [==============================] - 11s 359ms/step - loss: 0.8842 - acc: 0.7228 - val_loss: 0.9723 - val_a
cc: 0.6663
Epoch 24/50
32/32 [==============================] - ETA: 0s - loss: 0.9008 - acc: 0.6729
Epoch 24: val_loss improved from 0.97229 to 0.87410, saving model to models/model3_nobatchnorm
INFO:tensorflow:Assets written to: models/model3_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model3_nobatchnorm/assets
```

```
32/32 [==============================] - 11s 347ms/step - loss: 0.9008 - acc: 0.6729 - val_loss: 0.8741 - val_a
cc: 0.7071
Epoch 25/50

32/32 [==============================] - ETA: 0s - loss: 0.9123 - acc: 0.6855
Epoch 25: val_loss did not improve from 0.87410
32/32 [==============================] - 10s 316ms/step - loss: 0.9123 - acc: 0.6855 - val_loss: 0.9550 - val_a
cc: 0.6841
Epoch 26/50
32/32 [==============================] - ETA: 0s - loss: 0.8439 - acc: 0.7051
Epoch 26: val_loss improved from 0.87410 to 0.84050, saving model to models/model3_nobatchnorm
INFO:tensorflow:Assets written to: models/model3_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model3_nobatchnorm/assets
32/32 [==============================] - 10s 310ms/step - loss: 0.8439 - acc: 0.7051 - val_loss: 0.8405 - val_a
cc: 0.7312
Epoch 27/50
32/32 [==============================] - ETA: 0s - loss: 0.8056 - acc: 0.7208
Epoch 27: val_loss improved from 0.84050 to 0.82775, saving model to models/model3_nobatchnorm
INFO:tensorflow:Assets written to: models/model3_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model3_nobatchnorm/assets
32/32 [==============================] - 12s 374ms/step - loss: 0.8056 - acc: 0.7208 - val_loss: 0.8277 - val_a
cc: 0.7322
Epoch 28/50
32/32 [==============================] - ETA: 0s - loss: 0.8158 - acc: 0.7393
Epoch 28: val_loss did not improve from 0.82775
32/32 [==============================] - 10s 327ms/step - loss: 0.8158 - acc: 0.7393 - val_loss: 0.8369 - val_a
cc: 0.7113
Epoch 29/50
32/32 [==============================] - ETA: 0s - loss: 0.8437 - acc: 0.7080
Epoch 29: val_loss did not improve from 0.82775
32/32 [==============================] - 9s 297ms/step - loss: 0.8437 - acc: 0.7080 - val_loss: 0.8811 - val_ac
c: 0.7092
Epoch 30/50
32/32 [==============================] - ETA: 0s - loss: 0.7493 - acc: 0.7426
Epoch 30: val_loss did not improve from 0.82775
32/32 [==============================] - 8s 266ms/step - loss: 0.7493 - acc: 0.7426 - val_loss: 0.9332 - val_ac
c: 0.6925
Epoch 31/50
32/32 [==============================] - ETA: 0s - loss: 0.7229 - acc: 0.7441
Epoch 31: val_loss did not improve from 0.82775
32/32 [==============================] - 9s 288ms/step - loss: 0.7229 - acc: 0.7441 - val_loss: 0.8526 - val_ac
c: 0.7207
Epoch 32/50
32/32 [==============================] - ETA: 0s - loss: 0.7282 - acc: 0.7480
Epoch 32: val_loss improved from 0.82775 to 0.74871, saving model to models/model3_nobatchnorm
INFO:tensorflow:Assets written to: models/model3_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model3_nobatchnorm/assets
32/32 [==============================] - 12s 391ms/step - loss: 0.7282 - acc: 0.7480 - val_loss: 0.7487 - val_a
cc: 0.7563
Epoch 33/50
32/32 [==============================] - ETA: 0s - loss: 0.7714 - acc: 0.7246
Epoch 33: val_loss did not improve from 0.74871
32/32 [==============================] - 9s 295ms/step - loss: 0.7714 - acc: 0.7246 - val_loss: 0.7823 - val_ac
c: 0.7458
Epoch 34/50
32/32 [==============================] - ETA: 0s - loss: 0.6231 - acc: 0.7851
Epoch 34: val_loss improved from 0.74871 to 0.74466, saving model to models/model3_nobatchnorm
INFO:tensorflow:Assets written to: models/model3_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model3_nobatchnorm/assets
```

```
32/32 [==============================] - 12s 370ms/step - loss: 0.6231 - acc: 0.7851 - val_loss: 0.7447 - val_a
cc: 0.7479
Epoch 35/50
32/32 [==============================] - ETA: 0s - loss: 0.7369 - acc: 0.7305
Epoch 35: val_loss did not improve from 0.74466
32/32 [==============================] - 11s 351ms/step - loss: 0.7369 - acc: 0.7305 - val_loss: 0.8300 - val_a
cc: 0.7155
Epoch 36/50
32/32 [==============================] - ETA: 0s - loss: 0.6819 - acc: 0.7666
Epoch 36: val_loss did not improve from 0.74466
32/32 [==============================] - 9s 279ms/step - loss: 0.6819 - acc: 0.7666 - val_loss: 0.8427 - val_ac
c: 0.7238
Epoch 37/50
32/32 [==============================] - ETA: 0s - loss: 0.7340 - acc: 0.7363
Epoch 37: val_loss did not improve from 0.74466
32/32 [==============================] - 8s 240ms/step - loss: 0.7340 - acc: 0.7363 - val_loss: 0.8206 - val_ac
c: 0.7259
Epoch 38/50
32/32 [==============================] - ETA: 0s - loss: 0.6204 - acc: 0.8010
Epoch 38: val_loss did not improve from 0.74466
32/32 [==============================] - 9s 286ms/step - loss: 0.6204 - acc: 0.8010 - val_loss: 0.8673 - val_ac
c: 0.7155
Epoch 39/50
32/32 [==============================] - ETA: 0s - loss: 0.6003 - acc: 0.7959
Epoch 39: val_loss did not improve from 0.74466
32/32 [==============================] - 9s 295ms/step - loss: 0.6003 - acc: 0.7959 - val_loss: 0.7557 - val_ac
c: 0.7490
Epoch 40/50
32/32 [==============================] - ETA: 0s - loss: 0.6325 - acc: 0.7812
Epoch 40: val_loss did not improve from 0.74466
32/32 [==============================] - 11s 340ms/step - loss: 0.6325 - acc: 0.7812 - val_loss: 0.7548 - val_a
cc: 0.7458
Epoch 41/50
32/32 [==============================] - ETA: 0s - loss: 0.6104 - acc: 0.7891
Epoch 41: val_loss did not improve from 0.74466
32/32 [==============================] - 9s 299ms/step - loss: 0.6104 - acc: 0.7891 - val_loss: 0.8864 - val_ac
c: 0.6872
Epoch 42/50
32/32 [==============================] - ETA: 0s - loss: 0.6650 - acc: 0.7617
Epoch 42: val_loss did not improve from 0.74466
32/32 [==============================] - 10s 331ms/step - loss: 0.6650 - acc: 0.7617 - val_loss: 0.7743 - val_a
cc: 0.7385
Epoch 43/50
32/32 [==============================] - ETA: 0s - loss: 0.5441 - acc: 0.8223
Epoch 43: val_loss improved from 0.74466 to 0.71436, saving model to models/model3_nobatchnorm
INFO:tensorflow:Assets written to: models/model3_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model3_nobatchnorm/assets
32/32 [==============================] - 11s 348ms/step - loss: 0.5441 - acc: 0.8223 - val_loss: 0.7144 - val_a
cc: 0.7667
Epoch 44/50
32/32 [==============================] - ETA: 0s - loss: 0.5878 - acc: 0.8037
Epoch 44: val_loss did not improve from 0.71436
32/32 [==============================] - 11s 331ms/step - loss: 0.5878 - acc: 0.8037 - val_loss: 0.7323 - val_a
cc: 0.7490
Epoch 45/50
32/32 [==============================] - ETA: 0s - loss: 0.5213 - acc: 0.8139
Epoch 45: val_loss did not improve from 0.71436
32/32 [==============================] - 9s 272ms/step - loss: 0.5213 - acc: 0.8139 - val_loss: 0.7233 - val_ac
c: 0.7552
Epoch 46/50
32/32 [==============================] - ETA: 0s - loss: 0.5395 - acc: 0.8320
Epoch 46: val_loss improved from 0.71436 to 0.66713, saving model to models/model3_nobatchnorm
INFO:tensorflow:Assets written to: models/model3_nobatchnorm/assets
INFO:tensorflow:Assets written to: models/model3_nobatchnorm/assets
32/32 [==============================] - 11s 350ms/step - loss: 0.5395 - acc: 0.8320 - val_loss: 0.6671 - val_a
cc: 0.7741
Epoch 47/50
32/32 [==============================] - ETA: 0s - loss: 0.5324 - acc: 0.8252
Epoch 47: val_loss did not improve from 0.66713
32/32 [==============================] - 10s 317ms/step - loss: 0.5324 - acc: 0.8252 - val_loss: 0.6882 - val_a
cc: 0.7762
Epoch 48/50
32/32 [==============================] - ETA: 0s - loss: 0.5339 - acc: 0.8252
Epoch 48: val_loss did not improve from 0.66713
32/32 [==============================] - 9s 277ms/step - loss: 0.5339 - acc: 0.8252 - val_loss: 0.7077 - val_ac
c: 0.7615
Epoch 49/50
32/32 [==============================] - ETA: 0s - loss: 0.4937 - acc: 0.8307
Epoch 49: val_loss did not improve from 0.66713
32/32 [==============================] - 10s 308ms/step - loss: 0.4937 - acc: 0.8307 - val_loss: 0.7318 - val_a
cc: 0.7469
Epoch 50/50
32/32 [==============================] - ETA: 0s - loss: 0.5715 - acc: 0.7939
Epoch 50: val_loss did not improve from 0.66713
32/32 [==============================] - 9s 283ms/step - loss: 0.5715 - acc: 0.7939 - val_loss: 0.6972 - val_ac
c: 0.7636
```

In [27]:
```
# Classification report
```

```
def print_classification_report(true_labels, predictions):
    predicted_classes = np.argmax(predictions, axis=1)
    report = classification_report(true_labels.tolist(), predicted_classes.tolist())

    print("Classification Report:\n", report)
```

In [28]:
```
# Cargar arquitecturas de los modelos para cargar pesos en memoria
models_list = []
for experiment_name, config in scratch_experiments.items():
    print(f"Running Experiment: {experiment_name}")

    # Configurar el modelo utilizando las configuraciones
    block_configs = []
    for block_conf in config["model"]["conv_block_configs"]:
        block = ConvBlockConfig(block_conf["filters"],
                                block_conf["kernel_size"],
                                block_conf["use_maxpooling"],
                                block_conf["use_batchnorm"],
                                block_conf["dropout_value"],
                                block_conf["name"])
        block_configs.append(block)

    # Crear modelo
    model = create_model_with_configurations(block_configs, input_shape, num_classes)

    # Compilar modelo
    model.compile(
        loss = tf.keras.losses.categorical_crossentropy,
        optimizer = tf.keras.optimizers.Adam(0.0001),
        metrics = ['acc'])

    # Crear callbacks
    callbacks = get_callbacks(experiment_name)

    # Mostrar arquitectura
    print(model.summary())

    models_list.append(model)
```

```
Running Experiment: model1
Model: "sequential_6"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 block1 (Sequential)         (None, 112, 112, 64)      2048

 block2 (Sequential)         (None, 56, 56, 128)       74368

 block3 (Sequential)         (None, 28, 28, 256)       296192

 top_model_flatten (Flatten  (None, 200704)            0
 )

 top_model_dense_1 (Dense)   (None, 128)               25690240

 top_model_output (Dense)    (None, 12)                1548

=================================================================
Total params: 26064396 (99.43 MB)
Trainable params: 26063500 (99.42 MB)
Non-trainable params: 896 (3.50 KB)
_________________________________________________________________
None
Running Experiment: model1_nobatchnorm
Model: "sequential_7"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 block1 (Sequential)         (None, 112, 112, 64)      1792

 block2 (Sequential)         (None, 56, 56, 128)       73856

 block3 (Sequential)         (None, 28, 28, 256)       295168

 top_model_flatten (Flatten  (None, 200704)            0
 )

 top_model_dense_1 (Dense)   (None, 128)               25690240

 top_model_output (Dense)    (None, 12)                1548

=================================================================
Total params: 26062604 (99.42 MB)
Trainable params: 26062604 (99.42 MB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
None
Running Experiment: model2
```

```
Model: "sequential_8"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 block1 (Sequential)         (None, 112, 112, 64)      5120

 block2 (Sequential)         (None, 56, 56, 128)       205440

 top_model_flatten (Flatten  (None, 401408)            0
 )

 top_model_dense_1 (Dense)   (None, 128)               51380352

 top_model_output (Dense)    (None, 12)                1548

=================================================================
Total params: 51592460 (196.81 MB)
Trainable params: 51592076 (196.81 MB)
Non-trainable params: 384 (1.50 KB)
_________________________________________________________________
None
Running Experiment: model2_nobatchnorm
Model: "sequential_9"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 block1 (Sequential)         (None, 112, 112, 64)      4864

 block2 (Sequential)         (None, 56, 56, 128)       204928

 top_model_flatten (Flatten  (None, 401408)            0
 )

 top_model_dense_1 (Dense)   (None, 128)               51380352

 top_model_output (Dense)    (None, 12)                1548

=================================================================
Total params: 51591692 (196.81 MB)
Trainable params: 51591692 (196.81 MB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
None
Running Experiment: model3
Model: "sequential_10"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 block1 (Sequential)         (None, 112, 112, 64)      2048

 block2 (Sequential)         (None, 56, 56, 128)       74368

 block3 (Sequential)         (None, 28, 28, 256)       296192

 block4 (Sequential)         (None, 14, 14, 512)       1182208

 top_model_flatten (Flatten  (None, 100352)            0
 )

 top_model_dense_1 (Dense)   (None, 128)               12845184

 top_model_output (Dense)    (None, 12)                1548

=================================================================
Total params: 14401548 (54.94 MB)
Trainable params: 14399628 (54.93 MB)
Non-trainable params: 1920 (7.50 KB)
_________________________________________________________________
None
Running Experiment: model3_nobatchnorm
Model: "sequential_11"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 block1 (Sequential)         (None, 112, 112, 64)      1792

 block2 (Sequential)         (None, 56, 56, 128)       73856

 block3 (Sequential)         (None, 28, 28, 256)       295168

 block4 (Sequential)         (None, 14, 14, 512)       1180160

 top_model_flatten (Flatten  (None, 100352)            0
 )

 top_model_dense_1 (Dense)   (None, 128)               12845184

 top_model_output (Dense)    (None, 12)                1548
```

```
=================================================================
Total params: 14397708 (54.92 MB)
Trainable params: 14397708 (54.92 MB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
None
```

In [29]:
```python
# Cargar modelos en memoria

checkpoint_paths = [
    "models/model1",
    "models/model1_nobatchnorm",
    "models/model2",
    "models/model2_nobatchnorm",
    "models/model3",
    "models/model3_nobatchnorm",
]

predictions = []
for model, checkpoint_filepath in zip(models_list, checkpoint_paths):
    model.load_weights(checkpoint_filepath)

    model.summary()
    predictions.append(model.predict(valid_tfdataset))
```

```
Model: "sequential_6"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 block1 (Sequential)         (None, 112, 112, 64)      2048

 block2 (Sequential)         (None, 56, 56, 128)       74368

 block3 (Sequential)         (None, 28, 28, 256)       296192

 top_model_flatten (Flatten  (None, 200704)            0
 )

 top_model_dense_1 (Dense)   (None, 128)               25690240

 top_model_output (Dense)    (None, 12)                1548

2023-11-26 19:34:55.980413: W tensorflow/core/util/tensor_slice_reader.cc:98] Could not open models/model1: FAI
LED_PRECONDITION: models/model1; Is a directory: perhaps your file is in a different file format and you need t
o use a different restore operator?

=================================================================
Total params: 26064396 (99.43 MB)
Trainable params: 26063500 (99.42 MB)
Non-trainable params: 896 (3.50 KB)
_________________________________________________________________
30/30 [==============================] - 5s 159ms/step
Model: "sequential_7"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 block1 (Sequential)         (None, 112, 112, 64)      1792

 block2 (Sequential)         (None, 56, 56, 128)       73856

 block3 (Sequential)         (None, 28, 28, 256)       295168

 top_model_flatten (Flatten  (None, 200704)            0
 )

 top_model_dense_1 (Dense)   (None, 128)               25690240

 top_model_output (Dense)    (None, 12)                1548

=================================================================
Total params: 26062604 (99.42 MB)
Trainable params: 26062604 (99.42 MB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
2023-11-26 19:35:01.114545: W tensorflow/core/util/tensor_slice_reader.cc:98] Could not open models/model1_noba
tchnorm: FAILED_PRECONDITION: models/model1_nobatchnorm; Is a directory: perhaps your file is in a different fi
le format and you need to use a different restore operator?
30/30 [==============================] - 5s 148ms/step
2023-11-26 19:35:05.855373: W tensorflow/core/util/tensor_slice_reader.cc:98] Could not open models/model2: FAI
LED_PRECONDITION: models/model2; Is a directory: perhaps your file is in a different file format and you need t
o use a different restore operator?
```

```
Model: "sequential_8"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 block1 (Sequential)         (None, 112, 112, 64)      5120

 block2 (Sequential)         (None, 56, 56, 128)       205440

 top_model_flatten (Flatten  (None, 401408)            0
 )

 top_model_dense_1 (Dense)   (None, 128)               51380352

 top_model_output (Dense)    (None, 12)                1548

=================================================================
Total params: 51592460 (196.81 MB)
Trainable params: 51592076 (196.81 MB)
Non-trainable params: 384 (1.50 KB)
_________________________________________________________________
30/30 [==============================] - 5s 148ms/step
2023-11-26 19:35:10.757952: W tensorflow/core/util/tensor_slice_reader.cc:98] Could not open models/model2_noba
tchnorm: FAILED_PRECONDITION: models/model2_nobatchnorm; Is a directory: perhaps your file is in a different fi
le format and you need to use a different restore operator?
Model: "sequential_9"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 block1 (Sequential)         (None, 112, 112, 64)      4864

 block2 (Sequential)         (None, 56, 56, 128)       204928

 top_model_flatten (Flatten  (None, 401408)            0
 )

 top_model_dense_1 (Dense)   (None, 128)               51380352

 top_model_output (Dense)    (None, 12)                1548

=================================================================
Total params: 51591692 (196.81 MB)
Trainable params: 51591692 (196.81 MB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
30/30 [==============================] - 5s 148ms/step
Model: "sequential_10"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 block1 (Sequential)         (None, 112, 112, 64)      2048

 block2 (Sequential)         (None, 56, 56, 128)       74368

 block3 (Sequential)         (None, 28, 28, 256)       296192

 block4 (Sequential)         (None, 14, 14, 512)       1182208

 top_model_flatten (Flatten  (None, 100352)            0
 )

 top_model_dense_1 (Dense)   (None, 128)               12845184

 top_model_output (Dense)    (None, 12)                1548

=================================================================
Total params: 14401548 (54.94 MB)
Trainable params: 14399628 (54.93 MB)
Non-trainable params: 1920 (7.50 KB)
_________________________________________________________________
2023-11-26 19:35:15.647254: W tensorflow/core/util/tensor_slice_reader.cc:98] Could not open models/model3: FAI
LED_PRECONDITION: models/model3; Is a directory: perhaps your file is in a different file format and you need t
o use a different restore operator?
```

```
30/30 [==============================] - 5s 149ms/step
Model: "sequential_11"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 block1 (Sequential)         (None, 112, 112, 64)      1792

 block2 (Sequential)         (None, 56, 56, 128)       73856

 block3 (Sequential)         (None, 28, 28, 256)       295168

 block4 (Sequential)         (None, 14, 14, 512)       1180160

 top_model_flatten (Flatten  (None, 100352)            0
 )

 top_model_dense_1 (Dense)   (None, 128)               12845184

 top_model_output (Dense)    (None, 12)                1548

=================================================================
Total params: 14397708 (54.92 MB)
Trainable params: 14397708 (54.92 MB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
2023-11-26 19:35:20.731592: W tensorflow/core/util/tensor_slice_reader.cc:98] Could not open models/model3_noba
tchnorm: FAILED_PRECONDITION: models/model3_nobatchnorm; Is a directory: perhaps your file is in a different fi
le format and you need to use a different restore operator?
30/30 [==============================] - 4s 141ms/step
```

In [30]:

```python
# Mostrar classification report
for prediction, checkpoint_filepath in zip(predictions, checkpoint_paths):
    print(f"\nModel: {checkpoint_filepath}")
    print_classification_report(df_dataset_valid["label"].to_numpy(), prediction)
```

```
Model: models/model1
Classification Report:
              precision    recall  f1-score   support

           0       0.75      0.55      0.63       131
           1       0.89      0.76      0.82       123
           2       0.88      0.49      0.63       104
           3       0.90      0.84      0.87       100
           4       0.69      0.78      0.73        95
           5       0.81      0.77      0.79        78
           6       0.76      0.79      0.78        77
           7       0.79      0.93      0.86        58
           8       0.33      0.32      0.32        53
           9       0.45      0.83      0.58        47
          10       0.40      0.67      0.50        45
          11       0.72      0.96      0.82        45

    accuracy                           0.71       956
   macro avg       0.70      0.72      0.69       956
weighted avg       0.74      0.71      0.71       956


Model: models/model1_nobatchnorm
Classification Report:
              precision    recall  f1-score   support

           0       0.77      0.69      0.73       131
           1       0.76      0.86      0.81       123
           2       0.91      0.75      0.82       104
           3       0.79      0.87      0.83       100
           4       0.61      0.68      0.64        95
           5       0.89      0.82      0.85        78
           6       0.83      0.70      0.76        77
           7       0.74      0.88      0.80        58
           8       0.52      0.42      0.46        53
           9       0.60      0.55      0.58        47
          10       0.48      0.64      0.55        45
          11       0.76      0.76      0.76        45

    accuracy                           0.74       956
   macro avg       0.72      0.72      0.72       956
weighted avg       0.75      0.74      0.74       956


Model: models/model2
Classification Report:
              precision    recall  f1-score   support

           0       0.57      0.74      0.64       131
           1       0.84      0.52      0.64       123
           2       0.55      0.33      0.41       104
           3       0.80      0.81      0.81       100
           4       0.22      0.39      0.28        95
```

```
           5       0.69      0.62      0.65        78
           6       0.81      0.45      0.58        77
           7       0.64      0.74      0.69        58
           8       0.45      0.38      0.41        53
           9       0.40      0.17      0.24        47
          10       0.43      0.58      0.49        45
          11       0.44      0.76      0.56        45

    accuracy                           0.55       956
   macro avg       0.57      0.54      0.53       956
weighted avg       0.60      0.55      0.55       956


Model: models/model2_nobatchnorm
Classification Report:
              precision    recall  f1-score   support

           0       0.72      0.75      0.73       131
           1       0.90      0.77      0.83       123
           2       0.56      0.81      0.66       104
           3       0.85      0.87      0.86       100
           4       0.72      0.53      0.61        95
           5       0.81      0.86      0.83        78
           6       0.73      0.64      0.68        77
           7       0.80      0.84      0.82        58
           8       0.45      0.28      0.35        53
           9       0.61      0.47      0.53        47
          10       0.37      0.56      0.45        45
          11       0.72      0.76      0.74        45

    accuracy                           0.71       956
   macro avg       0.69      0.68      0.67       956
weighted avg       0.72      0.71      0.70       956


Model: models/model3
Classification Report:
              precision    recall  f1-score   support

           0       0.86      0.68      0.76       131
           1       0.95      0.93      0.94       123
           2       0.84      0.86      0.85       104
           3       0.92      0.91      0.91       100
           4       0.89      0.89      0.89        95
           5       0.93      0.86      0.89        78
           6       0.93      0.83      0.88        77
           7       0.86      0.88      0.87        58
           8       0.47      0.53      0.50        53
           9       0.65      0.87      0.75        47
          10       0.63      0.84      0.72        45
          11       0.84      0.93      0.88        45

    accuracy                           0.84       956
   macro avg       0.82      0.83      0.82       956
weighted avg       0.85      0.84      0.84       956


Model: models/model3_nobatchnorm
Classification Report:
              precision    recall  f1-score   support

           0       0.82      0.59      0.68       131
           1       0.86      0.90      0.88       123
           2       0.73      0.90      0.81       104
           3       0.95      0.88      0.91       100
           4       0.68      0.76      0.72        95
           5       0.93      0.81      0.86        78
           6       0.86      0.77      0.81        77
           7       0.76      0.91      0.83        58
           8       0.40      0.40      0.40        53
           9       0.76      0.68      0.72        47
          10       0.57      0.71      0.63        45
          11       0.79      0.84      0.82        45

    accuracy                           0.77       956
   macro avg       0.76      0.76      0.76       956
weighted avg       0.78      0.77      0.77       956
```

5.2 Monitorización del proceso de entrenamiento para la toma de decisiones (pre-entrenada)

DenseNet

In [31]:
```
from tensorflow.keras.applications import DenseNet121
```

```python
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense, Flatten

# Tamaño entrada
input_shape = (224, 224, 3)

# Callbacks y guardado de grádicas
callbacks = get_callbacks("DenseNet121")


# Cargar el modelo preentrenado de DenseNet121 sin incluir las capas densas (fully connected)
base_model = DenseNet121(weights='imagenet', include_top=False, input_shape=input_shape)


# Congelar las capas preentrenadas
for layer in base_model.layers:
    layer.trainable = False

# Crear un nuevo modelo Sequential
model = Sequential()

# Agregar la base preentrenada de DenseNet121
model.add(base_model)

# Añadir capas adicionales para la clasificación
model.add(Flatten())
model.add(Dense(128, activation='relu'))
model.add(Dense(12, activation='softmax'))

# Compilar el modelo
model.compile(optimizer='adam', loss='categorical_crossentropy', metrics=['acc'])

# Mostrar la arquitectura del modelo
model.summary()

history = model.fit(
    train_tfdataset.repeat(),
    steps_per_epoch = 32,
    epochs = 50,
    validation_data = valid_tfdataset,
    callbacks = callbacks
    )
```

```
Downloading data from https://storage.googleapis.com/tensorflow/keras-applications/densenet/densenet121_weights
_tf_dim_ordering_tf_kernels_notop.h5
29084464/29084464 [==============================] - 2s 0us/step
Model: "sequential_12"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 densenet121 (Functional)    (None, 7, 7, 1024)        7037504

 flatten (Flatten)           (None, 50176)             0

 dense (Dense)               (None, 128)               6422656

 dense_1 (Dense)             (None, 12)                1548

=================================================================
Total params: 13461708 (51.35 MB)
Trainable params: 6424204 (24.51 MB)
Non-trainable params: 7037504 (26.85 MB)
_________________________________________________________________
Epoch 1/50
32/32 [==============================] - ETA: 0s - loss: 5.0648 - acc: 0.2617
Epoch 1: val_loss improved from inf to 1.84584, saving model to models/DenseNet121
INFO:tensorflow:Assets written to: models/DenseNet121/assets
INFO:tensorflow:Assets written to: models/DenseNet121/assets
32/32 [==============================] - 43s 1s/step - loss: 5.0648 - acc: 0.2617 - val_loss: 1.8458 - val_acc:
0.3944
Epoch 2/50
32/32 [==============================] - ETA: 0s - loss: 1.6440 - acc: 0.4434
Epoch 2: val_loss improved from 1.84584 to 1.34165, saving model to models/DenseNet121
INFO:tensorflow:Assets written to: models/DenseNet121/assets
INFO:tensorflow:Assets written to: models/DenseNet121/assets
32/32 [==============================] - 39s 1s/step - loss: 1.6440 - acc: 0.4434 - val_loss: 1.3416 - val_acc:
0.5429
Epoch 3/50
32/32 [==============================] - ETA: 0s - loss: 1.2199 - acc: 0.6094
Epoch 3: val_loss improved from 1.34165 to 1.31440, saving model to models/DenseNet121
INFO:tensorflow:Assets written to: models/DenseNet121/assets
INFO:tensorflow:Assets written to: models/DenseNet121/assets
32/32 [==============================] - 37s 1s/step - loss: 1.2199 - acc: 0.6094 - val_loss: 1.3144 - val_acc:
0.5659
Epoch 4/50
32/32 [==============================] - ETA: 0s - loss: 1.0090 - acc: 0.6525
Epoch 4: val_loss improved from 1.31440 to 1.08237, saving model to models/DenseNet121
INFO:tensorflow:Assets written to: models/DenseNet121/assets
```

```
INFO:tensorflow:Assets written to: models/DenseNet121/assets
32/32 [==============================] - 35s 1s/step - loss: 1.0090 - acc: 0.6525 - val_loss: 1.0824 - val_acc:
0.6151
Epoch 5/50
32/32 [==============================] - ETA: 0s - loss: 0.8035 - acc: 0.7266
Epoch 5: val_loss improved from 1.08237 to 0.78110, saving model to models/DenseNet121
INFO:tensorflow:Assets written to: models/DenseNet121/assets
INFO:tensorflow:Assets written to: models/DenseNet121/assets
32/32 [==============================] - 36s 1s/step - loss: 0.8035 - acc: 0.7266 - val_loss: 0.7811 - val_acc:
0.7249
Epoch 6/50
32/32 [==============================] - ETA: 0s - loss: 0.7419 - acc: 0.7500
Epoch 6: val_loss improved from 0.78110 to 0.75672, saving model to models/DenseNet121
INFO:tensorflow:Assets written to: models/DenseNet121/assets
INFO:tensorflow:Assets written to: models/DenseNet121/assets
32/32 [==============================] - 39s 1s/step - loss: 0.7419 - acc: 0.7500 - val_loss: 0.7567 - val_acc:
0.7500
Epoch 7/50
32/32 [==============================] - ETA: 0s - loss: 0.6908 - acc: 0.7549
Epoch 7: val_loss improved from 0.75672 to 0.71590, saving model to models/DenseNet121
INFO:tensorflow:Assets written to: models/DenseNet121/assets
INFO:tensorflow:Assets written to: models/DenseNet121/assets
32/32 [==============================] - 35s 1s/step - loss: 0.6908 - acc: 0.7549 - val_loss: 0.7159 - val_acc:
0.7584
Epoch 8/50
32/32 [==============================] - ETA: 0s - loss: 0.6959 - acc: 0.7733
Epoch 8: val_loss did not improve from 0.71590
32/32 [==============================] - 8s 263ms/step - loss: 0.6959 - acc: 0.7733 - val_loss: 0.7267 - val_ac
c: 0.7469
Epoch 9/50
32/32 [==============================] - ETA: 0s - loss: 0.5365 - acc: 0.8184
Epoch 9: val_loss did not improve from 0.71590
32/32 [==============================] - 8s 258ms/step - loss: 0.5365 - acc: 0.8184 - val_loss: 0.7715 - val_ac
c: 0.7584
Epoch 10/50
32/32 [==============================] - ETA: 0s - loss: 0.5088 - acc: 0.8213
Epoch 10: val_loss improved from 0.71590 to 0.66193, saving model to models/DenseNet121
INFO:tensorflow:Assets written to: models/DenseNet121/assets
INFO:tensorflow:Assets written to: models/DenseNet121/assets
32/32 [==============================] - 34s 1s/step - loss: 0.5088 - acc: 0.8213 - val_loss: 0.6619 - val_acc:
0.7573
Epoch 11/50
32/32 [==============================] - ETA: 0s - loss: 0.6131 - acc: 0.8008
Epoch 11: val_loss did not improve from 0.66193
32/32 [==============================] - 8s 260ms/step - loss: 0.6131 - acc: 0.8008 - val_loss: 0.6630 - val_ac
c: 0.7699
Epoch 12/50
32/32 [==============================] - ETA: 0s - loss: 0.4185 - acc: 0.8673
Epoch 12: val_loss improved from 0.66193 to 0.62316, saving model to models/DenseNet121
INFO:tensorflow:Assets written to: models/DenseNet121/assets
INFO:tensorflow:Assets written to: models/DenseNet121/assets
32/32 [==============================] - 38s 1s/step - loss: 0.4185 - acc: 0.8673 - val_loss: 0.6232 - val_acc:
0.7730
Epoch 13/50
32/32 [==============================] - ETA: 0s - loss: 0.4282 - acc: 0.8457
Epoch 13: val_loss did not improve from 0.62316
32/32 [==============================] - 9s 287ms/step - loss: 0.4282 - acc: 0.8457 - val_loss: 0.6300 - val_ac
c: 0.7929
Epoch 14/50
32/32 [==============================] - ETA: 0s - loss: 0.4668 - acc: 0.8340
Epoch 14: val_loss did not improve from 0.62316
32/32 [==============================] - 8s 242ms/step - loss: 0.4668 - acc: 0.8340 - val_loss: 0.6337 - val_ac
c: 0.8065
Epoch 15/50
32/32 [==============================] - ETA: 0s - loss: 0.4470 - acc: 0.8287
Epoch 15: val_loss did not improve from 0.62316
32/32 [==============================] - 10s 326ms/step - loss: 0.4470 - acc: 0.8287 - val_loss: 0.6533 - val_a
cc: 0.7845
Epoch 16/50
32/32 [==============================] - ETA: 0s - loss: 0.3566 - acc: 0.8730
Epoch 16: val_loss improved from 0.62316 to 0.54595, saving model to models/DenseNet121
INFO:tensorflow:Assets written to: models/DenseNet121/assets
INFO:tensorflow:Assets written to: models/DenseNet121/assets
```

```
32/32 [==============================] - 36s 1s/step - loss: 0.3566 - acc: 0.8730 - val_loss: 0.5459 - val_acc:
0.8086
Epoch 17/50
32/32 [==============================] - ETA: 0s - loss: 0.3419 - acc: 0.8877
Epoch 17: val_loss did not improve from 0.54595
32/32 [==============================] - 9s 267ms/step - loss: 0.3419 - acc: 0.8877 - val_loss: 0.6170 - val_ac
c: 0.7877
Epoch 18/50
32/32 [==============================] - ETA: 0s - loss: 0.3070 - acc: 0.8857
Epoch 18: val_loss did not improve from 0.54595
32/32 [==============================] - 8s 250ms/step - loss: 0.3070 - acc: 0.8857 - val_loss: 0.5645 - val_ac
c: 0.8232
Epoch 19/50

31/32 [============================>.] - ETA: 0s - loss: 0.2981 - acc: 0.8906
Epoch 19: val_loss did not improve from 0.54595
32/32 [==============================] - 8s 264ms/step - loss: 0.2948 - acc: 0.8911 - val_loss: 0.5465 - val_ac
c: 0.8264
Epoch 20/50
32/32 [==============================] - ETA: 0s - loss: 0.3009 - acc: 0.8848
Epoch 20: val_loss improved from 0.54595 to 0.53457, saving model to models/DenseNet121
INFO:tensorflow:Assets written to: models/DenseNet121/assets
INFO:tensorflow:Assets written to: models/DenseNet121/assets
32/32 [==============================] - 38s 1s/step - loss: 0.3009 - acc: 0.8848 - val_loss: 0.5346 - val_acc:
0.8128
Epoch 21/50
32/32 [==============================] - ETA: 0s - loss: 0.3274 - acc: 0.8877
Epoch 21: val_loss improved from 0.53457 to 0.51804, saving model to models/DenseNet121
INFO:tensorflow:Assets written to: models/DenseNet121/assets
INFO:tensorflow:Assets written to: models/DenseNet121/assets
32/32 [==============================] - 40s 1s/step - loss: 0.3274 - acc: 0.8877 - val_loss: 0.5180 - val_acc:
0.8285
Epoch 22/50
32/32 [==============================] - ETA: 0s - loss: 0.2957 - acc: 0.8965
Epoch 22: val_loss did not improve from 0.51804
32/32 [==============================] - 8s 250ms/step - loss: 0.2957 - acc: 0.8965 - val_loss: 0.5268 - val_ac
c: 0.8243
Epoch 23/50
32/32 [==============================] - ETA: 0s - loss: 0.2332 - acc: 0.9218
Epoch 23: val_loss did not improve from 0.51804
32/32 [==============================] - 8s 261ms/step - loss: 0.2332 - acc: 0.9218 - val_loss: 0.5214 - val_ac
c: 0.8190
Epoch 24/50
32/32 [==============================] - ETA: 0s - loss: 0.2259 - acc: 0.9209
Epoch 24: val_loss improved from 0.51804 to 0.47747, saving model to models/DenseNet121
INFO:tensorflow:Assets written to: models/DenseNet121/assets
INFO:tensorflow:Assets written to: models/DenseNet121/assets
32/32 [==============================] - 35s 1s/step - loss: 0.2259 - acc: 0.9209 - val_loss: 0.4775 - val_acc:
0.8326
Epoch 25/50
32/32 [==============================] - ETA: 0s - loss: 0.2921 - acc: 0.8945
Epoch 25: val_loss did not improve from 0.47747
32/32 [==============================] - 7s 237ms/step - loss: 0.2921 - acc: 0.8945 - val_loss: 0.5799 - val_ac
c: 0.7971
Epoch 26/50
32/32 [==============================] - ETA: 0s - loss: 0.2990 - acc: 0.8916
Epoch 26: val_loss did not improve from 0.47747
32/32 [==============================] - 8s 264ms/step - loss: 0.2990 - acc: 0.8916 - val_loss: 0.4852 - val_ac
c: 0.8421
Epoch 27/50
32/32 [==============================] - ETA: 0s - loss: 0.2605 - acc: 0.9099
Epoch 27: val_loss did not improve from 0.47747
32/32 [==============================] - 9s 274ms/step - loss: 0.2605 - acc: 0.9099 - val_loss: 0.5193 - val_ac
c: 0.8232
Epoch 28/50
32/32 [==============================] - ETA: 0s - loss: 0.2582 - acc: 0.9131
Epoch 28: val_loss did not improve from 0.47747
32/32 [==============================] - 8s 265ms/step - loss: 0.2582 - acc: 0.9131 - val_loss: 0.4904 - val_ac
c: 0.8410
Epoch 29/50
32/32 [==============================] - ETA: 0s - loss: 0.2877 - acc: 0.8877
Epoch 29: val_loss did not improve from 0.47747
32/32 [==============================] - 8s 254ms/step - loss: 0.2877 - acc: 0.8877 - val_loss: 0.5342 - val_ac
c: 0.8232
Epoch 30/50
32/32 [==============================] - ETA: 0s - loss: 0.2714 - acc: 0.9089
Epoch 30: val_loss did not improve from 0.47747
32/32 [==============================] - 8s 257ms/step - loss: 0.2714 - acc: 0.9089 - val_loss: 0.5013 - val_ac
c: 0.8389
Epoch 31/50
32/32 [==============================] - ETA: 0s - loss: 0.2255 - acc: 0.9268
Epoch 31: val_loss did not improve from 0.47747
32/32 [==============================] - 8s 268ms/step - loss: 0.2255 - acc: 0.9268 - val_loss: 0.5929 - val_ac
c: 0.8117
Epoch 32/50
32/32 [==============================] - ETA: 0s - loss: 0.2335 - acc: 0.9189
Epoch 32: val_loss improved from 0.47747 to 0.47249, saving model to models/DenseNet121
INFO:tensorflow:Assets written to: models/DenseNet121/assets
```

```
INFO:tensorflow:Assets written to: models/DenseNet121/assets
32/32 [==============================] - 37s 1s/step - loss: 0.2335 - acc: 0.9189 - val_loss: 0.4725 - val_acc:
0.8441
Epoch 33/50
32/32 [==============================] - ETA: 0s - loss: 0.2505 - acc: 0.9131
Epoch 33: val_loss did not improve from 0.47249
32/32 [==============================] - 8s 239ms/step - loss: 0.2505 - acc: 0.9131 - val_loss: 0.4756 - val_ac
c: 0.8431
Epoch 34/50
32/32 [==============================] - ETA: 0s - loss: 0.2113 - acc: 0.9307
Epoch 34: val_loss did not improve from 0.47249
32/32 [==============================] - 8s 254ms/step - loss: 0.2113 - acc: 0.9307 - val_loss: 0.4964 - val_ac
c: 0.8305
Epoch 35/50
32/32 [==============================] - ETA: 0s - loss: 0.1847 - acc: 0.9355
Epoch 35: val_loss did not improve from 0.47249
32/32 [==============================] - 9s 281ms/step - loss: 0.1847 - acc: 0.9355 - val_loss: 0.5380 - val_ac
c: 0.8295
Epoch 36/50
32/32 [==============================] - ETA: 0s - loss: 0.2240 - acc: 0.9297
Epoch 36: val_loss did not improve from 0.47249
32/32 [==============================] - 8s 246ms/step - loss: 0.2240 - acc: 0.9297 - val_loss: 0.5382 - val_ac
c: 0.8295
Epoch 37/50
32/32 [==============================] - ETA: 0s - loss: 0.1994 - acc: 0.9336
Epoch 37: val_loss did not improve from 0.47249
32/32 [==============================] - 9s 272ms/step - loss: 0.1994 - acc: 0.9336 - val_loss: 0.5376 - val_ac
c: 0.8305
Epoch 38/50
32/32 [==============================] - ETA: 0s - loss: 0.1911 - acc: 0.9307
Epoch 38: val_loss did not improve from 0.47249
32/32 [==============================] - 9s 282ms/step - loss: 0.1911 - acc: 0.9307 - val_loss: 0.5213 - val_ac
c: 0.8358
Epoch 39/50
32/32 [==============================] - ETA: 0s - loss: 0.2523 - acc: 0.9170
Epoch 39: val_loss did not improve from 0.47249
32/32 [==============================] - 9s 292ms/step - loss: 0.2523 - acc: 0.9170 - val_loss: 0.5890 - val_ac
c: 0.8054
Epoch 40/50
32/32 [==============================] - ETA: 0s - loss: 0.1662 - acc: 0.9434
Epoch 40: val_loss did not improve from 0.47249
32/32 [==============================] - 8s 255ms/step - loss: 0.1662 - acc: 0.9434 - val_loss: 0.5785 - val_ac
c: 0.8274
Epoch 41/50
32/32 [==============================] - ETA: 0s - loss: 0.1921 - acc: 0.9337
Epoch 41: val_loss did not improve from 0.47249
32/32 [==============================] - 9s 279ms/step - loss: 0.1921 - acc: 0.9337 - val_loss: 0.6453 - val_ac
c: 0.7992
Epoch 42/50
32/32 [==============================] - ETA: 0s - loss: 0.2170 - acc: 0.9189
Epoch 42: val_loss did not improve from 0.47249
32/32 [==============================] - 9s 282ms/step - loss: 0.2170 - acc: 0.9189 - val_loss: 0.6051 - val_ac
c: 0.8274
Epoch 43/50
32/32 [==============================] - ETA: 0s - loss: 0.2009 - acc: 0.9229
Epoch 43: val_loss did not improve from 0.47249
32/32 [==============================] - 8s 264ms/step - loss: 0.2009 - acc: 0.9229 - val_loss: 0.5988 - val_ac
c: 0.8180
Epoch 44/50
32/32 [==============================] - ETA: 0s - loss: 0.1842 - acc: 0.9404
Epoch 44: val_loss did not improve from 0.47249
32/32 [==============================] - 7s 234ms/step - loss: 0.1842 - acc: 0.9404 - val_loss: 0.5624 - val_ac
c: 0.8295
Epoch 45/50
32/32 [==============================] - ETA: 0s - loss: 0.2374 - acc: 0.9228
Epoch 45: val_loss did not improve from 0.47249
32/32 [==============================] - 9s 287ms/step - loss: 0.2374 - acc: 0.9228 - val_loss: 0.7220 - val_ac
c: 0.7939
Epoch 46/50
31/32 [==============================>.] - ETA: 0s - loss: 0.2573 - acc: 0.9083
Epoch 46: val_loss did not improve from 0.47249
32/32 [==============================] - 9s 272ms/step - loss: 0.2535 - acc: 0.9092 - val_loss: 0.6066 - val_ac
c: 0.7887
Epoch 47/50
32/32 [==============================] - ETA: 0s - loss: 0.2198 - acc: 0.9189
Epoch 47: val_loss did not improve from 0.47249
32/32 [==============================] - 9s 282ms/step - loss: 0.2198 - acc: 0.9189 - val_loss: 0.6574 - val_ac
c: 0.8169
Epoch 48/50
32/32 [==============================] - ETA: 0s - loss: 0.2232 - acc: 0.9102
Epoch 48: val_loss did not improve from 0.47249
32/32 [==============================] - 8s 256ms/step - loss: 0.2232 - acc: 0.9102 - val_loss: 0.5815 - val_ac
c: 0.8285
Epoch 49/50
32/32 [==============================] - ETA: 0s - loss: 0.2478 - acc: 0.9218
Epoch 49: val_loss did not improve from 0.47249
32/32 [==============================] - 8s 271ms/step - loss: 0.2478 - acc: 0.9218 - val_loss: 0.6920 - val_ac
c: 0.8169
```

```
Epoch 50/50
32/32 [==============================] - ETA: 0s - loss: 0.1996 - acc: 0.9336
Epoch 50: val_loss did not improve from 0.47249
32/32 [==============================] - 8s 263ms/step - loss: 0.1996 - acc: 0.9336 - val_loss: 0.4909 - val_ac
c: 0.8536
```

Obtenemos métricas para el dataset de validación

In [70]:
```python
# Tamaño entrada
input_shape = (224, 224, 3)

# Callbacks y guardado de grádicas
callbacks = get_callbacks("DenseNet121")


# Cargar el modelo preentrenado de DenseNet121 sin incluir las capas densas (fully connected)
base_model = DenseNet121(weights='imagenet', include_top=False, input_shape=input_shape)


# Congelar las capas preentrenadas
for layer in base_model.layers:
    layer.trainable = False

# Crear un nuevo modelo Sequential
model = Sequential()

# Agregar la base preentrenada de DenseNet121
model.add(base_model)

# Añadir capas adicionales para la clasificación
model.add(Flatten())
model.add(Dense(128, activation='relu'))
model.add(Dense(12, activation='softmax'))

# Compilar el modelo
model.compile(optimizer='adam', loss='categorical_crossentropy', metrics=['acc'])

# Mostrar la arquitectura del modelo
model.summary()

# Sacar prediccion
model.load_weights("models/DenseNet121")
prediction = model.predict(valid_tfdataset)
```

```
Model: "sequential_20"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 densenet121 (Functional)    (None, 7, 7, 1024)        7037504

 flatten_8 (Flatten)         (None, 50176)             0

 dense_26 (Dense)            (None, 128)               6422656

 dense_27 (Dense)            (None, 12)                1548

=================================================================
Total params: 13461708 (51.35 MB)
Trainable params: 6424204 (24.51 MB)
Non-trainable params: 7037504 (26.85 MB)
_________________________________________________________________
2023-11-26 20:36:44.491259: W tensorflow/core/util/tensor_slice_reader.cc:98] Could not open models/DenseNet121
: FAILED_PRECONDITION: models/DenseNet121; Is a directory: perhaps your file is in a different file format and
you need to use a different restore operator?
30/30 [==============================] - 6s 159ms/step
```

In [71]:
```python
# Mostrar classification report
print("Classification DenseNet121")
print_classification_report(df_dataset_valid["label"].to_numpy(), prediction)
```

```
Classification DenseNet121
Classification Report:
              precision    recall  f1-score   support

           0       0.79      0.87      0.83       131
           1       0.86      0.88      0.87       123
           2       0.82      0.92      0.87       104
           3       0.90      0.94      0.92       100
           4       0.92      0.87      0.90        95
           5       0.91      0.94      0.92        78
           6       0.91      0.88      0.89        77
           7       0.96      0.78      0.86        58
           8       0.55      0.53      0.54        53
           9       0.81      0.62      0.70        47
          10       0.87      0.58      0.69        45
          11       0.77      0.96      0.85        45

    accuracy                           0.84       956
   macro avg       0.84      0.81      0.82       956
weighted avg       0.85      0.84      0.84       956
```

VGG16

In [35]:

```python
from tensorflow.keras.applications import VGG16

# Tamaño entrada
input_shape = (224, 224, 3)

# Callbacks y guardado de grádicas
callbacks = get_callbacks("VGG16")


# Cargar el modelo preentrenado de DenseNet121 sin incluir las capas densas (fully connected)
base_model = VGG16(weights='imagenet', include_top=False, input_shape=input_shape)


# Congelar las capas preentrenadas
for layer in base_model.layers:
    layer.trainable = False

# Crear un nuevo modelo Sequential
model = Sequential()

# Agregar la base preentrenada de VGG16
model.add(base_model)

# Añadir capas adicionales para la clasificación
model.add(Flatten())
model.add(Dense(128, activation='relu'))
model.add(Dense(12, activation='softmax'))

# Compilar el modelo
model.compile(optimizer='adam', loss='categorical_crossentropy', metrics=['acc'])

# Mostrar la arquitectura del modelo
model.summary()

history = model.fit(
    train_tfdataset.repeat(),
    steps_per_epoch = 32,
    epochs = 50,
    validation_data = valid_tfdataset,
    callbacks = callbacks
    )
```

```
Model: "sequential_13"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 vgg16 (Functional)          (None, 7, 7, 512)         14714688

 flatten_1 (Flatten)         (None, 25088)             0

 dense_2 (Dense)             (None, 128)               3211392

 dense_3 (Dense)             (None, 12)                1548

=================================================================
Total params: 17927628 (68.39 MB)
Trainable params: 3212940 (12.26 MB)
Non-trainable params: 14714688 (56.13 MB)
_________________________________________________________________
Epoch 1/50
32/32 [==============================] - ETA: 0s - loss: 2.9209 - acc: 0.2148
Epoch 1: val_loss improved from inf to 2.10990, saving model to models/VGG16
INFO:tensorflow:Assets written to: models/VGG16/assets
```

```
INFO:tensorflow:Assets written to: models/VGG16/assets
32/32 [==============================] - 14s 380ms/step - loss: 2.9209 - acc: 0.2148 - val_loss: 2.1099 - val_a
cc: 0.2939
Epoch 2/50
32/32 [==============================] - ETA: 0s - loss: 2.0168 - acc: 0.3096
Epoch 2: val_loss improved from 2.10990 to 1.86994, saving model to models/VGG16
INFO:tensorflow:Assets written to: models/VGG16/assets
INFO:tensorflow:Assets written to: models/VGG16/assets
32/32 [==============================] - 12s 370ms/step - loss: 2.0168 - acc: 0.3096 - val_loss: 1.8699 - val_a
cc: 0.4153
Epoch 3/50
32/32 [==============================] - ETA: 0s - loss: 1.8000 - acc: 0.4043
Epoch 3: val_loss improved from 1.86994 to 1.81284, saving model to models/VGG16
INFO:tensorflow:Assets written to: models/VGG16/assets
INFO:tensorflow:Assets written to: models/VGG16/assets
32/32 [==============================] - 11s 336ms/step - loss: 1.8000 - acc: 0.4043 - val_loss: 1.8128 - val_a
cc: 0.3672
Epoch 4/50
32/32 [==============================] - ETA: 0s - loss: 1.6699 - acc: 0.4416
Epoch 4: val_loss improved from 1.81284 to 1.62056, saving model to models/VGG16
INFO:tensorflow:Assets written to: models/VGG16/assets
INFO:tensorflow:Assets written to: models/VGG16/assets
32/32 [==============================] - 10s 311ms/step - loss: 1.6699 - acc: 0.4416 - val_loss: 1.6206 - val_a
cc: 0.4404
Epoch 5/50
32/32 [==============================] - ETA: 0s - loss: 1.4949 - acc: 0.5039
Epoch 5: val_loss improved from 1.62056 to 1.45303, saving model to models/VGG16
INFO:tensorflow:Assets written to: models/VGG16/assets
INFO:tensorflow:Assets written to: models/VGG16/assets
32/32 [==============================] - 11s 354ms/step - loss: 1.4949 - acc: 0.5039 - val_loss: 1.4530 - val_a
cc: 0.5481
Epoch 6/50
32/32 [==============================] - ETA: 0s - loss: 1.5012 - acc: 0.5107
Epoch 6: val_loss improved from 1.45303 to 1.38130, saving model to models/VGG16
INFO:tensorflow:Assets written to: models/VGG16/assets
INFO:tensorflow:Assets written to: models/VGG16/assets
32/32 [==============================] - 10s 322ms/step - loss: 1.5012 - acc: 0.5107 - val_loss: 1.3813 - val_a
cc: 0.5429
Epoch 7/50
32/32 [==============================] - ETA: 0s - loss: 1.3280 - acc: 0.5781
Epoch 7: val_loss improved from 1.38130 to 1.31300, saving model to models/VGG16
INFO:tensorflow:Assets written to: models/VGG16/assets
INFO:tensorflow:Assets written to: models/VGG16/assets
32/32 [==============================] - 10s 314ms/step - loss: 1.3280 - acc: 0.5781 - val_loss: 1.3130 - val_a
cc: 0.5565
Epoch 8/50
32/32 [==============================] - ETA: 0s - loss: 1.2789 - acc: 0.5703
Epoch 8: val_loss improved from 1.31300 to 1.25748, saving model to models/VGG16
INFO:tensorflow:Assets written to: models/VGG16/assets
INFO:tensorflow:Assets written to: models/VGG16/assets
32/32 [==============================] - 10s 308ms/step - loss: 1.2789 - acc: 0.5703 - val_loss: 1.2575 - val_a
cc: 0.5868
Epoch 9/50
32/32 [==============================] - ETA: 0s - loss: 1.2034 - acc: 0.5957
Epoch 9: val_loss improved from 1.25748 to 1.20577, saving model to models/VGG16
INFO:tensorflow:Assets written to: models/VGG16/assets
INFO:tensorflow:Assets written to: models/VGG16/assets
32/32 [==============================] - 10s 322ms/step - loss: 1.2034 - acc: 0.5957 - val_loss: 1.2058 - val_a
cc: 0.6109
Epoch 10/50
32/32 [==============================] - ETA: 0s - loss: 1.1307 - acc: 0.6221
Epoch 10: val_loss improved from 1.20577 to 1.13618, saving model to models/VGG16
INFO:tensorflow:Assets written to: models/VGG16/assets
INFO:tensorflow:Assets written to: models/VGG16/assets
32/32 [==============================] - 9s 299ms/step - loss: 1.1307 - acc: 0.6221 - val_loss: 1.1362 - val_ac
c: 0.6119
Epoch 11/50
32/32 [==============================] - ETA: 0s - loss: 1.0796 - acc: 0.6377
Epoch 11: val_loss improved from 1.13618 to 1.03131, saving model to models/VGG16
INFO:tensorflow:Assets written to: models/VGG16/assets
INFO:tensorflow:Assets written to: models/VGG16/assets
```

```
32/32 [==============================] - 11s 338ms/step - loss: 1.0796 - acc: 0.6377 - val_loss: 1.0313 - val_a
cc: 0.6642
Epoch 12/50
32/32 [==============================] - ETA: 0s - loss: 1.0075 - acc: 0.6743
Epoch 12: val_loss did not improve from 1.03131
32/32 [==============================] - 8s 256ms/step - loss: 1.0075 - acc: 0.6743 - val_loss: 1.0981 - val_ac
c: 0.6339
Epoch 13/50
32/32 [==============================] - ETA: 0s - loss: 0.9583 - acc: 0.6816
Epoch 13: val_loss did not improve from 1.03131
32/32 [==============================] - 9s 273ms/step - loss: 0.9583 - acc: 0.6816 - val_loss: 1.1152 - val_ac
c: 0.6119
Epoch 14/50

32/32 [==============================] - ETA: 0s - loss: 0.9892 - acc: 0.6768
Epoch 14: val_loss improved from 1.03131 to 1.02398, saving model to models/VGG16
INFO:tensorflow:Assets written to: models/VGG16/assets
INFO:tensorflow:Assets written to: models/VGG16/assets
32/32 [==============================] - 10s 319ms/step - loss: 0.9892 - acc: 0.6768 - val_loss: 1.0240 - val_a
cc: 0.6517
Epoch 15/50
32/32 [==============================] - ETA: 0s - loss: 0.9496 - acc: 0.6921
Epoch 15: val_loss improved from 1.02398 to 0.98896, saving model to models/VGG16
INFO:tensorflow:Assets written to: models/VGG16/assets
INFO:tensorflow:Assets written to: models/VGG16/assets
32/32 [==============================] - 11s 347ms/step - loss: 0.9496 - acc: 0.6921 - val_loss: 0.9890 - val_a
cc: 0.6496
Epoch 16/50
32/32 [==============================] - ETA: 0s - loss: 0.8691 - acc: 0.7295
Epoch 16: val_loss did not improve from 0.98896
32/32 [==============================] - 12s 395ms/step - loss: 0.8691 - acc: 0.7295 - val_loss: 1.0029 - val_a
cc: 0.6684
Epoch 17/50
32/32 [==============================] - ETA: 0s - loss: 0.8813 - acc: 0.7100
```

```
2023-11-26 19:59:05.281453: E tensorflow/compiler/xla/stream_executor/cuda/cuda_driver.cc:809] failed to alloc
1073741824 bytes on host: CUDA_ERROR_OUT_OF_MEMORY: out of memory
2023-11-26 19:59:05.281524: W ./tensorflow/compiler/xla/stream_executor/device_host_allocator.h:52] could not a
llocate pinned host memory of size: 1073741824
2023-11-26 19:59:05.440712: E tensorflow/compiler/xla/stream_executor/cuda/cuda_driver.cc:809] failed to alloc
966367744 bytes on host: CUDA_ERROR_OUT_OF_MEMORY: out of memory
2023-11-26 19:59:05.440769: W ./tensorflow/compiler/xla/stream_executor/device_host_allocator.h:52] could not a
llocate pinned host memory of size: 966367744
2023-11-26 19:59:05.599051: E tensorflow/compiler/xla/stream_executor/cuda/cuda_driver.cc:809] failed to alloc
869731072 bytes on host: CUDA_ERROR_OUT_OF_MEMORY: out of memory
2023-11-26 19:59:05.599099: W ./tensorflow/compiler/xla/stream_executor/device_host_allocator.h:52] could not a
llocate pinned host memory of size: 869731072
2023-11-26 19:59:05.742493: E tensorflow/compiler/xla/stream_executor/cuda/cuda_driver.cc:809] failed to alloc
782758144 bytes on host: CUDA_ERROR_OUT_OF_MEMORY: out of memory
2023-11-26 19:59:05.742555: W ./tensorflow/compiler/xla/stream_executor/device_host_allocator.h:52] could not a
llocate pinned host memory of size: 782758144
2023-11-26 19:59:05.884883: E tensorflow/compiler/xla/stream_executor/cuda/cuda_driver.cc:809] failed to alloc
704482304 bytes on host: CUDA_ERROR_OUT_OF_MEMORY: out of memory
2023-11-26 19:59:05.884935: W ./tensorflow/compiler/xla/stream_executor/device_host_allocator.h:52] could not a
llocate pinned host memory of size: 704482304
2023-11-26 19:59:06.037201: E tensorflow/compiler/xla/stream_executor/cuda/cuda_driver.cc:809] failed to alloc
634034176 bytes on host: CUDA_ERROR_OUT_OF_MEMORY: out of memory
2023-11-26 19:59:06.037257: W ./tensorflow/compiler/xla/stream_executor/device_host_allocator.h:52] could not a
llocate pinned host memory of size: 634034176
2023-11-26 19:59:06.171800: E tensorflow/compiler/xla/stream_executor/cuda/cuda_driver.cc:809] failed to alloc
570630912 bytes on host: CUDA_ERROR_OUT_OF_MEMORY: out of memory
2023-11-26 19:59:06.171856: W ./tensorflow/compiler/xla/stream_executor/device_host_allocator.h:52] could not a
llocate pinned host memory of size: 570630912
2023-11-26 19:59:06.300902: E tensorflow/compiler/xla/stream_executor/cuda/cuda_driver.cc:809] failed to alloc
513568000 bytes on host: CUDA_ERROR_OUT_OF_MEMORY: out of memory
2023-11-26 19:59:06.300946: W ./tensorflow/compiler/xla/stream_executor/device_host_allocator.h:52] could not a
llocate pinned host memory of size: 513568000
2023-11-26 19:59:06.429364: E tensorflow/compiler/xla/stream_executor/cuda/cuda_driver.cc:809] failed to alloc
462211328 bytes on host: CUDA_ERROR_OUT_OF_MEMORY: out of memory
2023-11-26 19:59:06.429422: W ./tensorflow/compiler/xla/stream_executor/device_host_allocator.h:52] could not a
llocate pinned host memory of size: 462211328
2023-11-26 19:59:06.598022: E tensorflow/compiler/xla/stream_executor/cuda/cuda_driver.cc:809] failed to alloc
415990272 bytes on host: CUDA_ERROR_OUT_OF_MEMORY: out of memory
2023-11-26 19:59:06.598066: W ./tensorflow/compiler/xla/stream_executor/device_host_allocator.h:52] could not a
llocate pinned host memory of size: 415990272
2023-11-26 19:59:06.737634: E tensorflow/compiler/xla/stream_executor/cuda/cuda_driver.cc:809] failed to alloc
374391296 bytes on host: CUDA_ERROR_OUT_OF_MEMORY: out of memory
2023-11-26 19:59:06.737689: W ./tensorflow/compiler/xla/stream_executor/device_host_allocator.h:52] could not a
llocate pinned host memory of size: 374391296
2023-11-26 19:59:06.901586: E tensorflow/compiler/xla/stream_executor/cuda/cuda_driver.cc:809] failed to alloc
336952320 bytes on host: CUDA_ERROR_OUT_OF_MEMORY: out of memory
2023-11-26 19:59:06.901637: W ./tensorflow/compiler/xla/stream_executor/device_host_allocator.h:52] could not a
llocate pinned host memory of size: 336952320
2023-11-26 19:59:07.052610: E tensorflow/compiler/xla/stream_executor/cuda/cuda_driver.cc:809] failed to alloc
303257088 bytes on host: CUDA_ERROR_OUT_OF_MEMORY: out of memory
2023-11-26 19:59:07.052658: W ./tensorflow/compiler/xla/stream_executor/device_host_allocator.h:52] could not a
llocate pinned host memory of size: 303257088
2023-11-26 19:59:07.172372: E tensorflow/compiler/xla/stream_executor/cuda/cuda_driver.cc:809] failed to alloc
272931584 bytes on host: CUDA_ERROR_OUT_OF_MEMORY: out of memory
2023-11-26 19:59:07.172420: W ./tensorflow/compiler/xla/stream_executor/device_host_allocator.h:52] could not a
llocate pinned host memory of size: 272931584
2023-11-26 19:59:07.311385: E tensorflow/compiler/xla/stream_executor/cuda/cuda_driver.cc:809] failed to alloc
245638656 bytes on host: CUDA_ERROR_OUT_OF_MEMORY: out of memory
2023-11-26 19:59:07.311448: W ./tensorflow/compiler/xla/stream_executor/device_host_allocator.h:52] could not a
llocate pinned host memory of size: 245638656
2023-11-26 19:59:07.455055: E tensorflow/compiler/xla/stream_executor/cuda/cuda_driver.cc:809] failed to alloc
221074944 bytes on host: CUDA_ERROR_OUT_OF_MEMORY: out of memory
2023-11-26 19:59:07.455109: W ./tensorflow/compiler/xla/stream_executor/device_host_allocator.h:52] could not a
llocate pinned host memory of size: 221074944
2023-11-26 19:59:07.586139: E tensorflow/compiler/xla/stream_executor/cuda/cuda_driver.cc:809] failed to alloc
198967552 bytes on host: CUDA_ERROR_OUT_OF_MEMORY: out of memory
2023-11-26 19:59:07.586190: W ./tensorflow/compiler/xla/stream_executor/device_host_allocator.h:52] could not a
llocate pinned host memory of size: 198967552
2023-11-26 19:59:07.722924: E tensorflow/compiler/xla/stream_executor/cuda/cuda_driver.cc:809] failed to alloc
179070976 bytes on host: CUDA_ERROR_OUT_OF_MEMORY: out of memory
2023-11-26 19:59:07.722981: W ./tensorflow/compiler/xla/stream_executor/device_host_allocator.h:52] could not a
llocate pinned host memory of size: 179070976
2023-11-26 19:59:07.868829: E tensorflow/compiler/xla/stream_executor/cuda/cuda_driver.cc:809] failed to alloc
161164032 bytes on host: CUDA_ERROR_OUT_OF_MEMORY: out of memory
2023-11-26 19:59:07.869001: W ./tensorflow/compiler/xla/stream_executor/device_host_allocator.h:52] could not a
llocate pinned host memory of size: 161164032
2023-11-26 19:59:08.002276: E tensorflow/compiler/xla/stream_executor/cuda/cuda_driver.cc:809] failed to alloc
145047808 bytes on host: CUDA_ERROR_OUT_OF_MEMORY: out of memory
2023-11-26 19:59:08.002329: W ./tensorflow/compiler/xla/stream_executor/device_host_allocator.h:52] could not a
llocate pinned host memory of size: 145047808
2023-11-26 19:59:08.135124: E tensorflow/compiler/xla/stream_executor/cuda/cuda_driver.cc:809] failed to alloc
130543104 bytes on host: CUDA_ERROR_OUT_OF_MEMORY: out of memory
2023-11-26 19:59:08.135169: W ./tensorflow/compiler/xla/stream_executor/device_host_allocator.h:52] could not a
llocate pinned host memory of size: 130543104
Epoch 17: val_loss improved from 0.98896 to 0.94046, saving model to models/VGG16
INFO:tensorflow:Assets written to: models/VGG16/assets
INFO:tensorflow:Assets written to: models/VGG16/assets
```

```
32/32 [==============================] - 13s 433ms/step - loss: 0.8813 - acc: 0.7100 - val_loss: 0.9405 - val_a
cc: 0.6872
Epoch 18/50
32/32 [==============================] - ETA: 0s - loss: 0.8699 - acc: 0.7256
Epoch 18: val_loss improved from 0.94046 to 0.86848, saving model to models/VGG16
INFO:tensorflow:Assets written to: models/VGG16/assets
INFO:tensorflow:Assets written to: models/VGG16/assets
32/32 [==============================] - 9s 297ms/step - loss: 0.8699 - acc: 0.7256 - val_loss: 0.8685 - val_ac
c: 0.6935
Epoch 19/50
32/32 [==============================] - ETA: 0s - loss: 0.7864 - acc: 0.7634
Epoch 19: val_loss did not improve from 0.86848
32/32 [==============================] - 8s 257ms/step - loss: 0.7864 - acc: 0.7634 - val_loss: 0.8971 - val_ac
c: 0.6851
Epoch 20/50
32/32 [==============================] - ETA: 0s - loss: 0.7654 - acc: 0.7432
Epoch 20: val_loss improved from 0.86848 to 0.84392, saving model to models/VGG16
INFO:tensorflow:Assets written to: models/VGG16/assets
INFO:tensorflow:Assets written to: models/VGG16/assets
32/32 [==============================] - 10s 315ms/step - loss: 0.7654 - acc: 0.7432 - val_loss: 0.8439 - val_a
cc: 0.7301
Epoch 21/50
32/32 [==============================] - ETA: 0s - loss: 0.7733 - acc: 0.7578
Epoch 21: val_loss did not improve from 0.84392
32/32 [==============================] - 8s 254ms/step - loss: 0.7733 - acc: 0.7578 - val_loss: 0.8445 - val_ac
c: 0.7123
Epoch 22/50
32/32 [==============================] - ETA: 0s - loss: 0.7629 - acc: 0.7559
Epoch 22: val_loss improved from 0.84392 to 0.82143, saving model to models/VGG16
INFO:tensorflow:Assets written to: models/VGG16/assets
INFO:tensorflow:Assets written to: models/VGG16/assets
32/32 [==============================] - 10s 326ms/step - loss: 0.7629 - acc: 0.7559 - val_loss: 0.8214 - val_a
cc: 0.7312
Epoch 23/50
32/32 [==============================] - ETA: 0s - loss: 0.6726 - acc: 0.7762
Epoch 23: val_loss improved from 0.82143 to 0.79773, saving model to models/VGG16
INFO:tensorflow:Assets written to: models/VGG16/assets
INFO:tensorflow:Assets written to: models/VGG16/assets
32/32 [==============================] - 11s 352ms/step - loss: 0.6726 - acc: 0.7762 - val_loss: 0.7977 - val_a
cc: 0.7207
Epoch 24/50
32/32 [==============================] - ETA: 0s - loss: 0.7315 - acc: 0.7646
Epoch 24: val_loss did not improve from 0.79773
32/32 [==============================] - 9s 275ms/step - loss: 0.7315 - acc: 0.7646 - val_loss: 0.8084 - val_ac
c: 0.7176
Epoch 25/50
32/32 [==============================] - ETA: 0s - loss: 0.6924 - acc: 0.7744
Epoch 25: val_loss improved from 0.79773 to 0.76293, saving model to models/VGG16
INFO:tensorflow:Assets written to: models/VGG16/assets
INFO:tensorflow:Assets written to: models/VGG16/assets
32/32 [==============================] - 9s 285ms/step - loss: 0.6924 - acc: 0.7744 - val_loss: 0.7629 - val_ac
c: 0.7385
Epoch 26/50
32/32 [==============================] - ETA: 0s - loss: 0.7049 - acc: 0.7686
Epoch 26: val_loss did not improve from 0.76293
32/32 [==============================] - 9s 288ms/step - loss: 0.7049 - acc: 0.7686 - val_loss: 0.7772 - val_ac
c: 0.7374
Epoch 27/50
32/32 [==============================] - ETA: 0s - loss: 0.6519 - acc: 0.8020
Epoch 27: val_loss did not improve from 0.76293
32/32 [==============================] - 9s 286ms/step - loss: 0.6519 - acc: 0.8020 - val_loss: 0.8930 - val_ac
c: 0.6925
Epoch 28/50
32/32 [==============================] - ETA: 0s - loss: 0.6338 - acc: 0.8018
Epoch 28: val_loss did not improve from 0.76293
32/32 [==============================] - 9s 279ms/step - loss: 0.6338 - acc: 0.8018 - val_loss: 0.8542 - val_ac
c: 0.6914
Epoch 29/50
32/32 [==============================] - ETA: 0s - loss: 0.6259 - acc: 0.7998
Epoch 29: val_loss improved from 0.76293 to 0.74871, saving model to models/VGG16
INFO:tensorflow:Assets written to: models/VGG16/assets
INFO:tensorflow:Assets written to: models/VGG16/assets
```

```
32/32 [==============================] - 10s 327ms/step - loss: 0.6259 - acc: 0.7998 - val_loss: 0.7487 - val_a
cc: 0.7427
Epoch 30/50
32/32 [==============================] - ETA: 0s - loss: 0.6794 - acc: 0.7762
Epoch 30: val_loss did not improve from 0.74871
32/32 [==============================] - 9s 283ms/step - loss: 0.6794 - acc: 0.7762 - val_loss: 0.7967 - val_ac
c: 0.7113
Epoch 31/50
32/32 [==============================] - ETA: 0s - loss: 0.5783 - acc: 0.8164
Epoch 31: val_loss did not improve from 0.74871
32/32 [==============================] - 10s 304ms/step - loss: 0.5783 - acc: 0.8164 - val_loss: 0.8804 - val_a
cc: 0.6946
Epoch 32/50
32/32 [==============================] - ETA: 0s - loss: 0.7461 - acc: 0.7393
Epoch 32: val_loss did not improve from 0.74871
32/32 [==============================] - 8s 272ms/step - loss: 0.7461 - acc: 0.7393 - val_loss: 0.9919 - val_ac
c: 0.6726
Epoch 33/50
32/32 [==============================] - ETA: 0s - loss: 0.6408 - acc: 0.7930
Epoch 33: val_loss did not improve from 0.74871
32/32 [==============================] - 8s 256ms/step - loss: 0.6408 - acc: 0.7930 - val_loss: 0.7654 - val_ac
c: 0.7312
Epoch 34/50
32/32 [==============================] - ETA: 0s - loss: 0.6262 - acc: 0.7980
Epoch 34: val_loss did not improve from 0.74871
32/32 [==============================] - 9s 279ms/step - loss: 0.6262 - acc: 0.7980 - val_loss: 0.7888 - val_ac
c: 0.7165
Epoch 35/50
32/32 [==============================] - ETA: 0s - loss: 0.6261 - acc: 0.7900
Epoch 35: val_loss improved from 0.74871 to 0.71677, saving model to models/VGG16
INFO:tensorflow:Assets written to: models/VGG16/assets
INFO:tensorflow:Assets written to: models/VGG16/assets
32/32 [==============================] - 10s 328ms/step - loss: 0.6261 - acc: 0.7900 - val_loss: 0.7168 - val_a
cc: 0.7437
Epoch 36/50
32/32 [==============================] - ETA: 0s - loss: 0.5108 - acc: 0.8389
Epoch 36: val_loss did not improve from 0.71677
32/32 [==============================] - 8s 266ms/step - loss: 0.5108 - acc: 0.8389 - val_loss: 0.7968 - val_ac
c: 0.7207
Epoch 37/50
32/32 [==============================] - ETA: 0s - loss: 0.5995 - acc: 0.8076
Epoch 37: val_loss did not improve from 0.71677
32/32 [==============================] - 9s 272ms/step - loss: 0.5995 - acc: 0.8076 - val_loss: 0.7178 - val_ac
c: 0.7458
Epoch 38/50
32/32 [==============================] - ETA: 0s - loss: 0.5337 - acc: 0.8257
Epoch 38: val_loss did not improve from 0.71677
32/32 [==============================] - 8s 270ms/step - loss: 0.5337 - acc: 0.8257 - val_loss: 0.7716 - val_ac
c: 0.7270
Epoch 39/50
32/32 [==============================] - ETA: 0s - loss: 0.5294 - acc: 0.8301
Epoch 39: val_loss did not improve from 0.71677
32/32 [==============================] - 9s 275ms/step - loss: 0.5294 - acc: 0.8301 - val_loss: 0.7299 - val_ac
c: 0.7490
Epoch 40/50
32/32 [==============================] - ETA: 0s - loss: 0.5810 - acc: 0.8125
Epoch 40: val_loss did not improve from 0.71677
32/32 [==============================] - 8s 256ms/step - loss: 0.5810 - acc: 0.8125 - val_loss: 0.8105 - val_ac
c: 0.7197
Epoch 41/50
32/32 [==============================] - ETA: 0s - loss: 0.5901 - acc: 0.8168
Epoch 41: val_loss did not improve from 0.71677
32/32 [==============================] - 9s 279ms/step - loss: 0.5901 - acc: 0.8168 - val_loss: 0.7856 - val_ac
c: 0.7333
Epoch 42/50
32/32 [==============================] - ETA: 0s - loss: 0.5469 - acc: 0.8271
Epoch 42: val_loss did not improve from 0.71677
32/32 [==============================] - 9s 288ms/step - loss: 0.5469 - acc: 0.8271 - val_loss: 0.7478 - val_ac
c: 0.7448
Epoch 43/50
32/32 [==============================] - ETA: 0s - loss: 0.5503 - acc: 0.8145
Epoch 43: val_loss did not improve from 0.71677
32/32 [==============================] - 12s 400ms/step - loss: 0.5503 - acc: 0.8145 - val_loss: 0.8011 - val_a
cc: 0.7270
Epoch 44/50
32/32 [==============================] - ETA: 0s - loss: 0.4901 - acc: 0.8496
Epoch 44: val_loss improved from 0.71677 to 0.68165, saving model to models/VGG16
INFO:tensorflow:Assets written to: models/VGG16/assets
INFO:tensorflow:Assets written to: models/VGG16/assets
```

```
32/32 [==============================] - 10s 308ms/step - loss: 0.4901 - acc: 0.8496 - val_loss: 0.6817 - val_a
cc: 0.7720
Epoch 45/50
32/32 [==============================] - ETA: 0s - loss: 0.5240 - acc: 0.8297
Epoch 45: val_loss did not improve from 0.68165
32/32 [==============================] - 9s 290ms/step - loss: 0.5240 - acc: 0.8297 - val_loss: 0.7368 - val_ac
c: 0.7531
Epoch 46/50
32/32 [==============================] - ETA: 0s - loss: 0.4587 - acc: 0.8486
Epoch 46: val_loss improved from 0.68165 to 0.65698, saving model to models/VGG16
INFO:tensorflow:Assets written to: models/VGG16/assets
INFO:tensorflow:Assets written to: models/VGG16/assets
32/32 [==============================] - 15s 470ms/step - loss: 0.4587 - acc: 0.8486 - val_loss: 0.6570 - val_a
cc: 0.7626
Epoch 47/50
32/32 [==============================] - ETA: 0s - loss: 0.4966 - acc: 0.8291
Epoch 47: val_loss improved from 0.65698 to 0.64047, saving model to models/VGG16
INFO:tensorflow:Assets written to: models/VGG16/assets
INFO:tensorflow:Assets written to: models/VGG16/assets
32/32 [==============================] - 10s 330ms/step - loss: 0.4966 - acc: 0.8291 - val_loss: 0.6405 - val_a
cc: 0.7688
Epoch 48/50
32/32 [==============================] - ETA: 0s - loss: 0.5241 - acc: 0.8252
Epoch 48: val_loss did not improve from 0.64047
32/32 [==============================] - 9s 275ms/step - loss: 0.5241 - acc: 0.8252 - val_loss: 0.8240 - val_ac
c: 0.7249
Epoch 49/50
32/32 [==============================] - ETA: 0s - loss: 0.4572 - acc: 0.8634
Epoch 49: val_loss did not improve from 0.64047
32/32 [==============================] - 9s 280ms/step - loss: 0.4572 - acc: 0.8634 - val_loss: 0.7891 - val_ac
c: 0.7144
Epoch 50/50
32/32 [==============================] - ETA: 0s - loss: 0.4641 - acc: 0.8516
Epoch 50: val_loss did not improve from 0.64047
32/32 [==============================] - 9s 285ms/step - loss: 0.4641 - acc: 0.8516 - val_loss: 0.6592 - val_ac
c: 0.7646
```

Obtenemos métricas para el dataset de validación

In [65]:

```python
# Cargar modelos en memoria

# Tamaño entrada
input_shape = (224, 224, 3)

# Callbacks y guardado de grádicas
callbacks = get_callbacks("VGG16")


# Cargar el modelo preentrenado de DenseNet121 sin incluir las capas densas (fully connected)
base_model = VGG16(weights='imagenet', include_top=False, input_shape=input_shape)


# Congelar las capas preentrenadas
for layer in base_model.layers:
    layer.trainable = False

# Crear un nuevo modelo Sequential
model = Sequential()

# Agregar la base preentrenada de VGG16
model.add(base_model)

# Añadir capas adicionales para la clasificación
model.add(Flatten())
model.add(Dense(128, activation='relu'))
model.add(Dense(12, activation='softmax'))

# Compilar el modelo
model.compile(optimizer='adam', loss='categorical_crossentropy', metrics=['acc'])

# Sacar prediccion
model.load_weights("models/VGG16")
model.summary()
prediction = model.predict(valid_tfdataset)
```

```
Model: "sequential_17"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 vgg16 (Functional)          (None, 7, 7, 512)         14714688

 flatten_5 (Flatten)         (None, 25088)             0

 dense_20 (Dense)            (None, 128)               3211392

 dense_21 (Dense)            (None, 12)                1548

=================================================================
Total params: 17927628 (68.39 MB)
Trainable params: 3212940 (12.26 MB)
Non-trainable params: 14714688 (56.13 MB)
_________________________________________________________________
```

```
2023-11-26 20:33:55.155807: W tensorflow/core/util/tensor_slice_reader.cc:98] Could not open models/VGG16: FAILED_PRECONDITION: models/VGG16; Is a directory: perhaps your file is in a different file format and you need to use a different restore operator?
30/30 [==============================] - 5s 155ms/step
```

In [66]:
```
# Mostrar classification report
print("Classification VGG16")
print_classification_report(df_dataset_valid["label"].to_numpy(), prediction)
```

```
Classification VGG16
Classification Report:
              precision    recall  f1-score   support

           0       0.66      0.84      0.74       131
           1       0.88      0.78      0.83       123
           2       0.74      0.72      0.73       104
           3       0.92      0.97      0.94       100
           4       0.72      0.72      0.72        95
           5       0.92      0.85      0.88        78
           6       0.80      0.88      0.84        77
           7       0.80      0.74      0.77        58
           8       0.61      0.47      0.53        53
           9       0.54      0.60      0.57        47
          10       0.69      0.56      0.62        45
          11       0.92      0.76      0.83        45

    accuracy                           0.77       956
   macro avg       0.77      0.74      0.75       956
weighted avg       0.77      0.77      0.77       956
```

EfficientNetV2 B0 (ImageNet Weights)

In [42]:
```
def load_efficienNetV2(
    num_classes = int,
    imagenet_weights = bool,
):
    """
    Loads EfficientNetV2 model with customized top layers for a specific number of classes.

    Args:
        num_classes (int): Number of classes for the final classification layer.

    Returns:
        tf.keras.models.Model: An instance of the EfficientNetV2 model with customized top layers.
    """
    if imagenet_weights:
        print(' > Loading iamgenet weights')
        weights_name = 'imagenet'
    else:
        weights_name =None

    redEffi = effnV2.EfficientNetV2B0(
        include_top=False,
        weights=weights_name,
        input_shape=(224, 224, 3),
    )

    x = redEffi.outputs[0]
    x_mean = GlobalAveragePooling2D()(x)
    x_max = GlobalMaxPooling2D()(x)
    x = Concatenate()([x_mean, x_max])
    x = Dropout(0.3)(x)

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

    model = tf.keras.models.Model(
            inputs=redEffi.inputs, outputs=[x])

    return model
```

In [ ]:
```
# Cargamos el modelo de prueba
model = load_efficienNetV2(
    num_classes=12,
    imagenet_weights=True)

model.summary()

model.compile(
    loss = tf.keras.losses.categorical_crossentropy,
    optimizer = tf.keras.optimizers.Adam(0.0001),
    metrics = ['acc'])

callbacks = get_callbacks("efficintB0_cw_imagenet")

# Entrenamos el modelo
history = model.fit(train_tfdataset.repeat(),
        validation_data=valid_tfdataset,
        class_weight = class_weight_dict,
        epochs = 50,
        steps_per_epoch=50,
        callbacks = callbacks,
        verbose=1)
```

```
 > Loading iamgenet weights
Model: "model_2"
```

Layer (type)	Output Shape	Param #	Connected to
input_3 (InputLayer)	[(None, 224, 224, 3)]	0	[]
rescaling_2 (Rescaling)	(None, 224, 224, 3)	0	['input_3[0][0]']
normalization_2 (Normalization)	(None, 224, 224, 3)	0	['rescaling_2[0][0]']
stem_conv (Conv2D)	(None, 112, 112, 32)	864	['normalization_2[0][0]']
stem_bn (BatchNormalization)	(None, 112, 112, 32)	128	['stem_conv[0][0]']
stem_activation (Activation)	(None, 112, 112, 32)	0	['stem_bn[0][0]']
block1a_project_conv (Conv2D)	(None, 112, 112, 16)	4608	['stem_activation[0][0]']
block1a_project_bn (BatchNormalization)	(None, 112, 112, 16)	64	['block1a_project_conv[0][0]']
block1a_project_activation (Activation)	(None, 112, 112, 16)	0	['block1a_project_bn[0][0]']
block2a_expand_conv (Conv2D)	(None, 56, 56, 64)	9216	['block1a_project_activation[0][0]']
block2a_expand_bn (BatchNormalization)	(None, 56, 56, 64)	256	['block2a_expand_conv[0][0]']
block2a_expand_activation (Activation)	(None, 56, 56, 64)	0	['block2a_expand_bn[0][0]']
block2a_project_conv (Conv2D)	(None, 56, 56, 32)	2048	['block2a_expand_activation[0][0]']
block2a_project_bn (BatchNormalization)	(None, 56, 56, 32)	128	['block2a_project_conv[0][0]']
block2b_expand_conv (Conv2D)	(None, 56, 56, 128)	36864	['block2a_project_bn[0][0]']
block2b_expand_bn (BatchNormalization)	(None, 56, 56, 128)	512	['block2b_expand_conv[0][0]']
block2b_expand_activation (Activation)	(None, 56, 56, 128)	0	['block2b_expand_bn[0][0]']
block2b_project_conv (Conv2D)	(None, 56, 56, 32)	4096	['block2b_expand_activation[0][0]']
block2b_project_bn (BatchNormalization)	(None, 56, 56, 32)	128	['block2b_project_conv[0][0]']
block2b_drop (Dropout)	(None, 56, 56, 32)	0	['block2b_project_bn[0][0]']
block2b_add (Add)	(None, 56, 56, 32)	0	['block2b_drop[0][0]', 'block2a_project_bn[0][0]']
block3a_expand_conv (Conv2	(None, 28, 28, 128)	36864	['block2b_add[0][0]']

```
D)

block3a_expand_bn (BatchNo  (None, 28, 28, 128)          512       ['block3a_expand_conv[0][0]']
rmalization)

block3a_expand_activation   (None, 28, 28, 128)          0         ['block3a_expand_bn[0][0]']
(Activation)

block3a_project_conv (Conv  (None, 28, 28, 48)           6144      ['block3a_expand_activation[0]
2D)                                                                 [0]']

block3a_project_bn (BatchN  (None, 28, 28, 48)           192       ['block3a_project_conv[0][0]']
ormalization)

block3b_expand_conv (Conv2  (None, 28, 28, 192)          82944     ['block3a_project_bn[0][0]']
D)

block3b_expand_bn (BatchNo  (None, 28, 28, 192)          768       ['block3b_expand_conv[0][0]']
rmalization)

block3b_expand_activation   (None, 28, 28, 192)          0         ['block3b_expand_bn[0][0]']
(Activation)

block3b_project_conv (Conv  (None, 28, 28, 48)           9216      ['block3b_expand_activation[0]
2D)                                                                 [0]']

block3b_project_bn (BatchN  (None, 28, 28, 48)           192       ['block3b_project_conv[0][0]']
ormalization)

block3b_drop (Dropout)      (None, 28, 28, 48)           0         ['block3b_project_bn[0][0]']

block3b_add (Add)           (None, 28, 28, 48)           0         ['block3b_drop[0][0]',
                                                                    'block3a_project_bn[0][0]']

block4a_expand_conv (Conv2  (None, 28, 28, 192)          9216      ['block3b_add[0][0]']
D)

block4a_expand_bn (BatchNo  (None, 28, 28, 192)          768       ['block4a_expand_conv[0][0]']
rmalization)

block4a_expand_activation   (None, 28, 28, 192)          0         ['block4a_expand_bn[0][0]']
(Activation)

block4a_dwconv2 (Depthwise  (None, 14, 14, 192)          1728      ['block4a_expand_activation[0]
Conv2D)                                                             [0]']

block4a_bn (BatchNormaliza  (None, 14, 14, 192)          768       ['block4a_dwconv2[0][0]']
tion)

block4a_activation (Activa  (None, 14, 14, 192)          0         ['block4a_bn[0][0]']
tion)

block4a_se_squeeze (Global  (None, 192)                  0         ['block4a_activation[0][0]']
AveragePooling2D)

block4a_se_reshape (Reshap  (None, 1, 1, 192)            0         ['block4a_se_squeeze[0][0]']
e)

block4a_se_reduce (Conv2D)  (None, 1, 1, 12)             2316      ['block4a_se_reshape[0][0]']

block4a_se_expand (Conv2D)  (None, 1, 1, 192)            2496      ['block4a_se_reduce[0][0]']

block4a_se_excite (Multipl  (None, 14, 14, 192)          0         ['block4a_activation[0][0]',
y)                                                                  'block4a_se_expand[0][0]']

block4a_project_conv (Conv  (None, 14, 14, 96)           18432     ['block4a_se_excite[0][0]']
2D)

block4a_project_bn (BatchN  (None, 14, 14, 96)           384       ['block4a_project_conv[0][0]']
ormalization)

block4b_expand_conv (Conv2  (None, 14, 14, 384)          36864     ['block4a_project_bn[0][0]']
D)

block4b_expand_bn (BatchNo  (None, 14, 14, 384)          1536      ['block4b_expand_conv[0][0]']
rmalization)

block4b_expand_activation   (None, 14, 14, 384)          0         ['block4b_expand_bn[0][0]']
(Activation)

block4b_dwconv2 (Depthwise  (None, 14, 14, 384)          3456      ['block4b_expand_activation[0]
Conv2D)                                                             [0]']

block4b_bn (BatchNormaliza  (None, 14, 14, 384)          1536      ['block4b_dwconv2[0][0]']
tion)

block4b_activation (Activa  (None, 14, 14, 384)          0         ['block4b_bn[0][0]']
tion)
```

```
block4b_se_squeeze (Global  (None, 384)                 0         ['block4b_activation[0][0]']
AveragePooling2D)

block4b_se_reshape (Reshap  (None, 1, 1, 384)           0         ['block4b_se_squeeze[0][0]']
e)

block4b_se_reduce (Conv2D)  (None, 1, 1, 24)            9240      ['block4b_se_reshape[0][0]']

block4b_se_expand (Conv2D)  (None, 1, 1, 384)           9600      ['block4b_se_reduce[0][0]']

block4b_se_excite (Multipl  (None, 14, 14, 384)         0         ['block4b_activation[0][0]',
y)                                                                  'block4b_se_expand[0][0]']

block4b_project_conv (Conv  (None, 14, 14, 96)          36864     ['block4b_se_excite[0][0]']
2D)

block4b_project_bn (BatchN  (None, 14, 14, 96)          384       ['block4b_project_conv[0][0]']
ormalization)

block4b_drop (Dropout)      (None, 14, 14, 96)          0         ['block4b_project_bn[0][0]']

block4b_add (Add)           (None, 14, 14, 96)          0         ['block4b_drop[0][0]',
                                                                    'block4a_project_bn[0][0]']

block4c_expand_conv (Conv2  (None, 14, 14, 384)         36864     ['block4b_add[0][0]']
D)

block4c_expand_bn (BatchNo  (None, 14, 14, 384)         1536      ['block4c_expand_conv[0][0]']
rmalization)

block4c_expand_activation   (None, 14, 14, 384)         0         ['block4c_expand_bn[0][0]']
(Activation)

block4c_dwconv2 (Depthwise  (None, 14, 14, 384)         3456      ['block4c_expand_activation[0]
Conv2D)                                                           [0]']

block4c_bn (BatchNormaliza  (None, 14, 14, 384)         1536      ['block4c_dwconv2[0][0]']
tion)

block4c_activation (Activa  (None, 14, 14, 384)         0         ['block4c_bn[0][0]']
tion)

block4c_se_squeeze (Global  (None, 384)                 0         ['block4c_activation[0][0]']
AveragePooling2D)

block4c_se_reshape (Reshap  (None, 1, 1, 384)           0         ['block4c_se_squeeze[0][0]']
e)

block4c_se_reduce (Conv2D)  (None, 1, 1, 24)            9240      ['block4c_se_reshape[0][0]']

block4c_se_expand (Conv2D)  (None, 1, 1, 384)           9600      ['block4c_se_reduce[0][0]']

block4c_se_excite (Multipl  (None, 14, 14, 384)         0         ['block4c_activation[0][0]',
y)                                                                  'block4c_se_expand[0][0]']

block4c_project_conv (Conv  (None, 14, 14, 96)          36864     ['block4c_se_excite[0][0]']
2D)

block4c_project_bn (BatchN  (None, 14, 14, 96)          384       ['block4c_project_conv[0][0]']
ormalization)

block4c_drop (Dropout)      (None, 14, 14, 96)          0         ['block4c_project_bn[0][0]']

block4c_add (Add)           (None, 14, 14, 96)          0         ['block4c_drop[0][0]',
                                                                    'block4b_add[0][0]']

block5a_expand_conv (Conv2  (None, 14, 14, 576)         55296     ['block4c_add[0][0]']
D)

block5a_expand_bn (BatchNo  (None, 14, 14, 576)         2304      ['block5a_expand_conv[0][0]']
rmalization)

block5a_expand_activation   (None, 14, 14, 576)         0         ['block5a_expand_bn[0][0]']
(Activation)

block5a_dwconv2 (Depthwise  (None, 14, 14, 576)         5184      ['block5a_expand_activation[0]
Conv2D)                                                           [0]']

block5a_bn (BatchNormaliza  (None, 14, 14, 576)         2304      ['block5a_dwconv2[0][0]']
tion)

block5a_activation (Activa  (None, 14, 14, 576)         0         ['block5a_bn[0][0]']
tion)

block5a_se_squeeze (Global  (None, 576)                 0         ['block5a_activation[0][0]']
AveragePooling2D)

block5a_se_reshape (Reshap  (None, 1, 1, 576)           0         ['block5a_se_squeeze[0][0]']
e)
```

```
block5a_se_reduce (Conv2D)  (None, 1, 1, 24)            13848     ['block5a_se_reshape[0][0]']

block5a_se_expand (Conv2D)  (None, 1, 1, 576)           14400     ['block5a_se_reduce[0][0]']

block5a_se_excite (Multipl  (None, 14, 14, 576)         0         ['block5a_activation[0][0]',
y)                                                                  'block5a_se_expand[0][0]']

block5a_project_conv (Conv  (None, 14, 14, 112)         64512     ['block5a_se_excite[0][0]']
2D)

block5a_project_bn (BatchN  (None, 14, 14, 112)         448       ['block5a_project_conv[0][0]']
ormalization)

block5b_expand_conv (Conv2  (None, 14, 14, 672)         75264     ['block5a_project_bn[0][0]']
D)

block5b_expand_bn (BatchNo  (None, 14, 14, 672)         2688      ['block5b_expand_conv[0][0]']
rmalization)

block5b_expand_activation   (None, 14, 14, 672)         0         ['block5b_expand_bn[0][0]']
(Activation)

block5b_dwconv2 (Depthwise  (None, 14, 14, 672)         6048      ['block5b_expand_activation[0]
Conv2D)                                                           [0]']

block5b_bn (BatchNormaliza  (None, 14, 14, 672)         2688      ['block5b_dwconv2[0][0]']
tion)

block5b_activation (Activa  (None, 14, 14, 672)         0         ['block5b_bn[0][0]']
tion)

block5b_se_squeeze (Global  (None, 672)                 0         ['block5b_activation[0][0]']
AveragePooling2D)

block5b_se_reshape (Reshap  (None, 1, 1, 672)           0         ['block5b_se_squeeze[0][0]']
e)

block5b_se_reduce (Conv2D)  (None, 1, 1, 28)            18844     ['block5b_se_reshape[0][0]']

block5b_se_expand (Conv2D)  (None, 1, 1, 672)           19488     ['block5b_se_reduce[0][0]']

block5b_se_excite (Multipl  (None, 14, 14, 672)         0         ['block5b_activation[0][0]',
y)                                                                  'block5b_se_expand[0][0]']

block5b_project_conv (Conv  (None, 14, 14, 112)         75264     ['block5b_se_excite[0][0]']
2D)

block5b_project_bn (BatchN  (None, 14, 14, 112)         448       ['block5b_project_conv[0][0]']
ormalization)

block5b_drop (Dropout)      (None, 14, 14, 112)         0         ['block5b_project_bn[0][0]']

block5b_add (Add)           (None, 14, 14, 112)         0         ['block5b_drop[0][0]',
                                                                    'block5a_project_bn[0][0]']

block5c_expand_conv (Conv2  (None, 14, 14, 672)         75264     ['block5b_add[0][0]']
D)

block5c_expand_bn (BatchNo  (None, 14, 14, 672)         2688      ['block5c_expand_conv[0][0]']
rmalization)

block5c_expand_activation   (None, 14, 14, 672)         0         ['block5c_expand_bn[0][0]']
(Activation)

block5c_dwconv2 (Depthwise  (None, 14, 14, 672)         6048      ['block5c_expand_activation[0]
Conv2D)                                                           [0]']

block5c_bn (BatchNormaliza  (None, 14, 14, 672)         2688      ['block5c_dwconv2[0][0]']
tion)

block5c_activation (Activa  (None, 14, 14, 672)         0         ['block5c_bn[0][0]']
tion)

block5c_se_squeeze (Global  (None, 672)                 0         ['block5c_activation[0][0]']
AveragePooling2D)

block5c_se_reshape (Reshap  (None, 1, 1, 672)           0         ['block5c_se_squeeze[0][0]']
e)

block5c_se_reduce (Conv2D)  (None, 1, 1, 28)            18844     ['block5c_se_reshape[0][0]']

block5c_se_expand (Conv2D)  (None, 1, 1, 672)           19488     ['block5c_se_reduce[0][0]']

block5c_se_excite (Multipl  (None, 14, 14, 672)         0         ['block5c_activation[0][0]',
y)                                                                  'block5c_se_expand[0][0]']

block5c_project_conv (Conv  (None, 14, 14, 112)         75264     ['block5c_se_excite[0][0]']
2D)
```

```
block5c_project_bn (BatchN  (None, 14, 14, 112)          448       ['block5c_project_conv[0][0]']
ormalization)

block5c_drop (Dropout)      (None, 14, 14, 112)          0         ['block5c_project_bn[0][0]']

block5c_add (Add)           (None, 14, 14, 112)          0         ['block5c_drop[0][0]',
                                                                    'block5b_add[0][0]']

block5d_expand_conv (Conv2  (None, 14, 14, 672)          75264     ['block5c_add[0][0]']
D)

block5d_expand_bn (BatchNo  (None, 14, 14, 672)          2688      ['block5d_expand_conv[0][0]']
rmalization)

block5d_expand_activation   (None, 14, 14, 672)          0         ['block5d_expand_bn[0][0]']
(Activation)

block5d_dwconv2 (Depthwise  (None, 14, 14, 672)          6048      ['block5d_expand_activation[0]
Conv2D)                                                             [0]']

block5d_bn (BatchNormaliza  (None, 14, 14, 672)          2688      ['block5d_dwconv2[0][0]']
tion)

block5d_activation (Activa  (None, 14, 14, 672)          0         ['block5d_bn[0][0]']
tion)

block5d_se_squeeze (Global  (None, 672)                  0         ['block5d_activation[0][0]']
AveragePooling2D)

block5d_se_reshape (Reshap  (None, 1, 1, 672)            0         ['block5d_se_squeeze[0][0]']
e)

block5d_se_reduce (Conv2D)  (None, 1, 1, 28)             18844     ['block5d_se_reshape[0][0]']

block5d_se_expand (Conv2D)  (None, 1, 1, 672)            19488     ['block5d_se_reduce[0][0]']

block5d_se_excite (Multipl  (None, 14, 14, 672)          0         ['block5d_activation[0][0]',
y)                                                                  'block5d_se_expand[0][0]']

block5d_project_conv (Conv  (None, 14, 14, 112)          75264     ['block5d_se_excite[0][0]']
2D)

block5d_project_bn (BatchN  (None, 14, 14, 112)          448       ['block5d_project_conv[0][0]']
ormalization)

block5d_drop (Dropout)      (None, 14, 14, 112)          0         ['block5d_project_bn[0][0]']

block5d_add (Add)           (None, 14, 14, 112)          0         ['block5d_drop[0][0]',
                                                                    'block5c_add[0][0]']

block5e_expand_conv (Conv2  (None, 14, 14, 672)          75264     ['block5d_add[0][0]']
D)

block5e_expand_bn (BatchNo  (None, 14, 14, 672)          2688      ['block5e_expand_conv[0][0]']
rmalization)

block5e_expand_activation   (None, 14, 14, 672)          0         ['block5e_expand_bn[0][0]']
(Activation)

block5e_dwconv2 (Depthwise  (None, 14, 14, 672)          6048      ['block5e_expand_activation[0]
Conv2D)                                                             [0]']

block5e_bn (BatchNormaliza  (None, 14, 14, 672)          2688      ['block5e_dwconv2[0][0]']
tion)

block5e_activation (Activa  (None, 14, 14, 672)          0         ['block5e_bn[0][0]']
tion)

block5e_se_squeeze (Global  (None, 672)                  0         ['block5e_activation[0][0]']
AveragePooling2D)

block5e_se_reshape (Reshap  (None, 1, 1, 672)            0         ['block5e_se_squeeze[0][0]']
e)

block5e_se_reduce (Conv2D)  (None, 1, 1, 28)             18844     ['block5e_se_reshape[0][0]']

block5e_se_expand (Conv2D)  (None, 1, 1, 672)            19488     ['block5e_se_reduce[0][0]']

block5e_se_excite (Multipl  (None, 14, 14, 672)          0         ['block5e_activation[0][0]',
y)                                                                  'block5e_se_expand[0][0]']

block5e_project_conv (Conv  (None, 14, 14, 112)          75264     ['block5e_se_excite[0][0]']
2D)

block5e_project_bn (BatchN  (None, 14, 14, 112)          448       ['block5e_project_conv[0][0]']
ormalization)

block5e_drop (Dropout)      (None, 14, 14, 112)          0         ['block5e_project_bn[0][0]']
```

```
block5e_add (Add)           (None, 14, 14, 112)          0         ['block5e_drop[0][0]',
                                                                    'block5d_add[0][0]']

block6a_expand_conv (Conv2  (None, 14, 14, 672)          75264     ['block5e_add[0][0]']
D)

block6a_expand_bn (BatchNo  (None, 14, 14, 672)          2688      ['block6a_expand_conv[0][0]']
rmalization)

block6a_expand_activation   (None, 14, 14, 672)          0         ['block6a_expand_bn[0][0]']
(Activation)

block6a_dwconv2 (Depthwise  (None, 7, 7, 672)            6048      ['block6a_expand_activation[0]
Conv2D)                                                             [0]']

block6a_bn (BatchNormaliza  (None, 7, 7, 672)            2688      ['block6a_dwconv2[0][0]']
tion)

block6a_activation (Activa  (None, 7, 7, 672)            0         ['block6a_bn[0][0]']
tion)

block6a_se_squeeze (Global  (None, 672)                  0         ['block6a_activation[0][0]']
AveragePooling2D)

block6a_se_reshape (Reshap  (None, 1, 1, 672)            0         ['block6a_se_squeeze[0][0]']
e)

block6a_se_reduce (Conv2D)  (None, 1, 1, 28)             18844     ['block6a_se_reshape[0][0]']

block6a_se_expand (Conv2D)  (None, 1, 1, 672)            19488     ['block6a_se_reduce[0][0]']

block6a_se_excite (Multipl  (None, 7, 7, 672)            0         ['block6a_activation[0][0]',
y)                                                                  'block6a_se_expand[0][0]']

block6a_project_conv (Conv  (None, 7, 7, 192)            129024    ['block6a_se_excite[0][0]']
2D)

block6a_project_bn (BatchN  (None, 7, 7, 192)            768       ['block6a_project_conv[0][0]']
ormalization)

block6b_expand_conv (Conv2  (None, 7, 7, 1152)           221184    ['block6a_project_bn[0][0]']
D)

block6b_expand_bn (BatchNo  (None, 7, 7, 1152)           4608      ['block6b_expand_conv[0][0]']
rmalization)

block6b_expand_activation   (None, 7, 7, 1152)           0         ['block6b_expand_bn[0][0]']
(Activation)

block6b_dwconv2 (Depthwise  (None, 7, 7, 1152)           10368     ['block6b_expand_activation[0]
Conv2D)                                                             [0]']

block6b_bn (BatchNormaliza  (None, 7, 7, 1152)           4608      ['block6b_dwconv2[0][0]']
tion)

block6b_activation (Activa  (None, 7, 7, 1152)           0         ['block6b_bn[0][0]']
tion)

block6b_se_squeeze (Global  (None, 1152)                 0         ['block6b_activation[0][0]']
AveragePooling2D)

block6b_se_reshape (Reshap  (None, 1, 1, 1152)           0         ['block6b_se_squeeze[0][0]']
e)

block6b_se_reduce (Conv2D)  (None, 1, 1, 48)             55344     ['block6b_se_reshape[0][0]']

block6b_se_expand (Conv2D)  (None, 1, 1, 1152)           56448     ['block6b_se_reduce[0][0]']

block6b_se_excite (Multipl  (None, 7, 7, 1152)           0         ['block6b_activation[0][0]',
y)                                                                  'block6b_se_expand[0][0]']

block6b_project_conv (Conv  (None, 7, 7, 192)            221184    ['block6b_se_excite[0][0]']
2D)

block6b_project_bn (BatchN  (None, 7, 7, 192)            768       ['block6b_project_conv[0][0]']
ormalization)

block6b_drop (Dropout)      (None, 7, 7, 192)            0         ['block6b_project_bn[0][0]']

block6b_add (Add)           (None, 7, 7, 192)            0         ['block6b_drop[0][0]',
                                                                    'block6a_project_bn[0][0]']

block6c_expand_conv (Conv2  (None, 7, 7, 1152)           221184    ['block6b_add[0][0]']
D)

block6c_expand_bn (BatchNo  (None, 7, 7, 1152)           4608      ['block6c_expand_conv[0][0]']
rmalization)
```

```
block6c_expand_activation   (None, 7, 7, 1152)          0         ['block6c_expand_bn[0][0]']
(Activation)

block6c_dwconv2 (Depthwise  (None, 7, 7, 1152)          10368     ['block6c_expand_activation[0]
Conv2D)                                                           [0]']

block6c_bn (BatchNormaliza  (None, 7, 7, 1152)          4608      ['block6c_dwconv2[0][0]']
tion)

block6c_activation (Activa  (None, 7, 7, 1152)          0         ['block6c_bn[0][0]']
tion)

block6c_se_squeeze (Global  (None, 1152)                0         ['block6c_activation[0][0]']
AveragePooling2D)

block6c_se_reshape (Reshap  (None, 1, 1, 1152)          0         ['block6c_se_squeeze[0][0]']
e)

block6c_se_reduce (Conv2D)  (None, 1, 1, 48)            55344     ['block6c_se_reshape[0][0]']

block6c_se_expand (Conv2D)  (None, 1, 1, 1152)          56448     ['block6c_se_reduce[0][0]']

block6c_se_excite (Multipl  (None, 7, 7, 1152)          0         ['block6c_activation[0][0]',
y)                                                                 'block6c_se_expand[0][0]']

block6c_project_conv (Conv  (None, 7, 7, 192)           221184    ['block6c_se_excite[0][0]']
2D)

block6c_project_bn (BatchN  (None, 7, 7, 192)           768       ['block6c_project_conv[0][0]']
ormalization)

block6c_drop (Dropout)      (None, 7, 7, 192)           0         ['block6c_project_bn[0][0]']

block6c_add (Add)           (None, 7, 7, 192)           0         ['block6c_drop[0][0]',
                                                                   'block6b_add[0][0]']

block6d_expand_conv (Conv2  (None, 7, 7, 1152)          221184    ['block6c_add[0][0]']
D)

block6d_expand_bn (BatchNo  (None, 7, 7, 1152)          4608      ['block6d_expand_conv[0][0]']
rmalization)

block6d_expand_activation   (None, 7, 7, 1152)          0         ['block6d_expand_bn[0][0]']
(Activation)

block6d_dwconv2 (Depthwise  (None, 7, 7, 1152)          10368     ['block6d_expand_activation[0]
Conv2D)                                                           [0]']

block6d_bn (BatchNormaliza  (None, 7, 7, 1152)          4608      ['block6d_dwconv2[0][0]']
tion)

block6d_activation (Activa  (None, 7, 7, 1152)          0         ['block6d_bn[0][0]']
tion)

block6d_se_squeeze (Global  (None, 1152)                0         ['block6d_activation[0][0]']
AveragePooling2D)

block6d_se_reshape (Reshap  (None, 1, 1, 1152)          0         ['block6d_se_squeeze[0][0]']
e)

block6d_se_reduce (Conv2D)  (None, 1, 1, 48)            55344     ['block6d_se_reshape[0][0]']

block6d_se_expand (Conv2D)  (None, 1, 1, 1152)          56448     ['block6d_se_reduce[0][0]']

block6d_se_excite (Multipl  (None, 7, 7, 1152)          0         ['block6d_activation[0][0]',
y)                                                                 'block6d_se_expand[0][0]']

block6d_project_conv (Conv  (None, 7, 7, 192)           221184    ['block6d_se_excite[0][0]']
2D)

block6d_project_bn (BatchN  (None, 7, 7, 192)           768       ['block6d_project_conv[0][0]']
ormalization)

block6d_drop (Dropout)      (None, 7, 7, 192)           0         ['block6d_project_bn[0][0]']

block6d_add (Add)           (None, 7, 7, 192)           0         ['block6d_drop[0][0]',
                                                                   'block6c_add[0][0]']

block6e_expand_conv (Conv2  (None, 7, 7, 1152)          221184    ['block6d_add[0][0]']
D)

block6e_expand_bn (BatchNo  (None, 7, 7, 1152)          4608      ['block6e_expand_conv[0][0]']
rmalization)

block6e_expand_activation   (None, 7, 7, 1152)          0         ['block6e_expand_bn[0][0]']
(Activation)

block6e_dwconv2 (Depthwise  (None, 7, 7, 1152)          10368     ['block6e_expand_activation[0]
Conv2D)                                                           [0]']
```

```
block6e_bn (BatchNormaliza  (None, 7, 7, 1152)          4608      ['block6e_dwconv2[0][0]']
tion)

block6e_activation (Activa  (None, 7, 7, 1152)          0         ['block6e_bn[0][0]']
tion)

block6e_se_squeeze (Global  (None, 1152)                0         ['block6e_activation[0][0]']
AveragePooling2D)

block6e_se_reshape (Reshap  (None, 1, 1, 1152)          0         ['block6e_se_squeeze[0][0]']
e)

block6e_se_reduce (Conv2D)  (None, 1, 1, 48)            55344     ['block6e_se_reshape[0][0]']

block6e_se_expand (Conv2D)  (None, 1, 1, 1152)          56448     ['block6e_se_reduce[0][0]']

block6e_se_excite (Multipl  (None, 7, 7, 1152)          0         ['block6e_activation[0][0]',
y)                                                                  'block6e_se_expand[0][0]']

block6e_project_conv (Conv  (None, 7, 7, 192)           221184    ['block6e_se_excite[0][0]']
2D)

block6e_project_bn (BatchN  (None, 7, 7, 192)           768       ['block6e_project_conv[0][0]']
ormalization)

block6e_drop (Dropout)      (None, 7, 7, 192)           0         ['block6e_project_bn[0][0]']

block6e_add (Add)           (None, 7, 7, 192)           0         ['block6e_drop[0][0]',
                                                                    'block6d_add[0][0]']

block6f_expand_conv (Conv2  (None, 7, 7, 1152)          221184    ['block6e_add[0][0]']
D)

block6f_expand_bn (BatchNo  (None, 7, 7, 1152)          4608      ['block6f_expand_conv[0][0]']
rmalization)

block6f_expand_activation   (None, 7, 7, 1152)          0         ['block6f_expand_bn[0][0]']
(Activation)

block6f_dwconv2 (Depthwise  (None, 7, 7, 1152)          10368     ['block6f_expand_activation[0]
Conv2D)                                                           [0]']

block6f_bn (BatchNormaliza  (None, 7, 7, 1152)          4608      ['block6f_dwconv2[0][0]']
tion)

block6f_activation (Activa  (None, 7, 7, 1152)          0         ['block6f_bn[0][0]']
tion)

block6f_se_squeeze (Global  (None, 1152)                0         ['block6f_activation[0][0]']
AveragePooling2D)

block6f_se_reshape (Reshap  (None, 1, 1, 1152)          0         ['block6f_se_squeeze[0][0]']
e)

block6f_se_reduce (Conv2D)  (None, 1, 1, 48)            55344     ['block6f_se_reshape[0][0]']

block6f_se_expand (Conv2D)  (None, 1, 1, 1152)          56448     ['block6f_se_reduce[0][0]']

block6f_se_excite (Multipl  (None, 7, 7, 1152)          0         ['block6f_activation[0][0]',
y)                                                                  'block6f_se_expand[0][0]']

block6f_project_conv (Conv  (None, 7, 7, 192)           221184    ['block6f_se_excite[0][0]']
2D)

block6f_project_bn (BatchN  (None, 7, 7, 192)           768       ['block6f_project_conv[0][0]']
ormalization)

block6f_drop (Dropout)      (None, 7, 7, 192)           0         ['block6f_project_bn[0][0]']

block6f_add (Add)           (None, 7, 7, 192)           0         ['block6f_drop[0][0]',
                                                                    'block6e_add[0][0]']

block6g_expand_conv (Conv2  (None, 7, 7, 1152)          221184    ['block6f_add[0][0]']
D)

block6g_expand_bn (BatchNo  (None, 7, 7, 1152)          4608      ['block6g_expand_conv[0][0]']
rmalization)

block6g_expand_activation   (None, 7, 7, 1152)          0         ['block6g_expand_bn[0][0]']
(Activation)

block6g_dwconv2 (Depthwise  (None, 7, 7, 1152)          10368     ['block6g_expand_activation[0]
Conv2D)                                                           [0]']

block6g_bn (BatchNormaliza  (None, 7, 7, 1152)          4608      ['block6g_dwconv2[0][0]']
tion)

block6g_activation (Activa  (None, 7, 7, 1152)          0         ['block6g_bn[0][0]']
```

```
tion)

block6g_se_squeeze (Global  (None, 1152)                0         ['block6g_activation[0][0]']
AveragePooling2D)

block6g_se_reshape (Reshap  (None, 1, 1, 1152)          0         ['block6g_se_squeeze[0][0]']
e)

block6g_se_reduce (Conv2D)  (None, 1, 1, 48)            55344     ['block6g_se_reshape[0][0]']

block6g_se_expand (Conv2D)  (None, 1, 1, 1152)          56448     ['block6g_se_reduce[0][0]']

block6g_se_excite (Multipl  (None, 7, 7, 1152)          0         ['block6g_activation[0][0]',
y)                                                                  'block6g_se_expand[0][0]']

block6g_project_conv (Conv  (None, 7, 7, 192)           221184    ['block6g_se_excite[0][0]']
2D)

block6g_project_bn (BatchN  (None, 7, 7, 192)           768       ['block6g_project_conv[0][0]']
ormalization)

block6g_drop (Dropout)      (None, 7, 7, 192)           0         ['block6g_project_bn[0][0]']

block6g_add (Add)           (None, 7, 7, 192)           0         ['block6g_drop[0][0]',
                                                                    'block6f_add[0][0]']

block6h_expand_conv (Conv2  (None, 7, 7, 1152)          221184    ['block6g_add[0][0]']
D)

block6h_expand_bn (BatchNo  (None, 7, 7, 1152)          4608      ['block6h_expand_conv[0][0]']
rmalization)

block6h_expand_activation   (None, 7, 7, 1152)          0         ['block6h_expand_bn[0][0]']
(Activation)

block6h_dwconv2 (Depthwise  (None, 7, 7, 1152)          10368     ['block6h_expand_activation[0]
Conv2D)                                                           [0]']

block6h_bn (BatchNormaliza  (None, 7, 7, 1152)          4608      ['block6h_dwconv2[0][0]']
tion)

block6h_activation (Activa  (None, 7, 7, 1152)          0         ['block6h_bn[0][0]']
tion)

block6h_se_squeeze (Global  (None, 1152)                0         ['block6h_activation[0][0]']
AveragePooling2D)

block6h_se_reshape (Reshap  (None, 1, 1, 1152)          0         ['block6h_se_squeeze[0][0]']
e)

block6h_se_reduce (Conv2D)  (None, 1, 1, 48)            55344     ['block6h_se_reshape[0][0]']

block6h_se_expand (Conv2D)  (None, 1, 1, 1152)          56448     ['block6h_se_reduce[0][0]']

block6h_se_excite (Multipl  (None, 7, 7, 1152)          0         ['block6h_activation[0][0]',
y)                                                                  'block6h_se_expand[0][0]']

block6h_project_conv (Conv  (None, 7, 7, 192)           221184    ['block6h_se_excite[0][0]']
2D)

block6h_project_bn (BatchN  (None, 7, 7, 192)           768       ['block6h_project_conv[0][0]']
ormalization)

block6h_drop (Dropout)      (None, 7, 7, 192)           0         ['block6h_project_bn[0][0]']

block6h_add (Add)           (None, 7, 7, 192)           0         ['block6h_drop[0][0]',
                                                                    'block6g_add[0][0]']

top_conv (Conv2D)           (None, 7, 7, 1280)          245760    ['block6h_add[0][0]']

top_bn (BatchNormalization  (None, 7, 7, 1280)          5120      ['top_conv[0][0]']
)

top_activation (Activation  (None, 7, 7, 1280)          0         ['top_bn[0][0]']
)

global_average_pooling2d_2  (None, 1280)                0         ['top_activation[0][0]']
 (GlobalAveragePooling2D)

global_max_pooling2d_2 (Gl  (None, 1280)                0         ['top_activation[0][0]']
obalMaxPooling2D)

concatenate_2 (Concatenate  (None, 2560)                0         ['global_average_pooling2d_2[0
)                                                                 ][0]',
                                                                    'global_max_pooling2d_2[0][0]
                                                                  ']

dropout_2 (Dropout)         (None, 2560)                0         ['concatenate_2[0][0]']
```

```
 dense_2 (Dense)             (None, 12)                30732     ['dropout_2[0][0]']

==================================================================================================
Total params: 5950044 (22.70 MB)
Trainable params: 5889436 (22.47 MB)
Non-trainable params: 60608 (236.75 KB)
__________________________________________________________________________________________________
Epoch 1/50
50/50 [==============================] - ETA: 0s - loss: 4.4812 - acc: 0.1256
Epoch 1: val_loss improved from inf to 3.59153, saving model to models\efficintB0_cw_imagenet
INFO:tensorflow:Assets written to: models\efficintB0_cw_imagenet\assets
INFO:tensorflow:Assets written to: models\efficintB0_cw_imagenet\assets
50/50 [==============================] - 148s 3s/step - loss: 4.4812 - acc: 0.1256 - val_loss: 3.5915 - val_acc
: 0.1088
Epoch 2/50
50/50 [==============================] - ETA: 0s - loss: 2.9424 - acc: 0.2544
Epoch 2: val_loss improved from 3.59153 to 2.28200, saving model to models\efficintB0_cw_imagenet
INFO:tensorflow:Assets written to: models\efficintB0_cw_imagenet\assets
INFO:tensorflow:Assets written to: models\efficintB0_cw_imagenet\assets
50/50 [==============================] - 130s 3s/step - loss: 2.9424 - acc: 0.2544 - val_loss: 2.2820 - val_acc
: 0.2981
Epoch 3/50
50/50 [==============================] - ETA: 0s - loss: 2.0486 - acc: 0.3897
Epoch 3: val_loss improved from 2.28200 to 1.90023, saving model to models\efficintB0_cw_imagenet
INFO:tensorflow:Assets written to: models\efficintB0_cw_imagenet\assets
INFO:tensorflow:Assets written to: models\efficintB0_cw_imagenet\assets
50/50 [==============================] - 129s 3s/step - loss: 2.0486 - acc: 0.3897 - val_loss: 1.9002 - val_acc
: 0.3630
Epoch 4/50
50/50 [==============================] - ETA: 0s - loss: 1.5630 - acc: 0.5250
Epoch 4: val_loss improved from 1.90023 to 0.72259, saving model to models\efficintB0_cw_imagenet
INFO:tensorflow:Assets written to: models\efficintB0_cw_imagenet\assets
INFO:tensorflow:Assets written to: models\efficintB0_cw_imagenet\assets
50/50 [==============================] - 130s 3s/step - loss: 1.5630 - acc: 0.5250 - val_loss: 0.7226 - val_acc
: 0.7458
Epoch 5/50
50/50 [==============================] - ETA: 0s - loss: 1.2692 - acc: 0.5984
Epoch 5: val_loss did not improve from 0.72259
50/50 [==============================] - 114s 2s/step - loss: 1.2692 - acc: 0.5984 - val_loss: 1.0895 - val_acc
: 0.6318
Epoch 6/50
50/50 [==============================] - ETA: 0s - loss: 0.9674 - acc: 0.6819
Epoch 6: val_loss did not improve from 0.72259
50/50 [==============================] - 115s 2s/step - loss: 0.9674 - acc: 0.6819 - val_loss: 0.7446 - val_acc
: 0.7395
Epoch 7/50
50/50 [==============================] - ETA: 0s - loss: 0.8878 - acc: 0.6988
Epoch 7: val_loss did not improve from 0.72259
50/50 [==============================] - 115s 2s/step - loss: 0.8878 - acc: 0.6988 - val_loss: 1.2229 - val_acc
: 0.5628
Epoch 8/50
50/50 [==============================] - ETA: 0s - loss: 0.7413 - acc: 0.7478
Epoch 8: val_loss did not improve from 0.72259
50/50 [==============================] - 114s 2s/step - loss: 0.7413 - acc: 0.7478 - val_loss: 0.9181 - val_acc
: 0.6977
Epoch 9/50
50/50 [==============================] - ETA: 0s - loss: 0.6625 - acc: 0.7713
Epoch 9: val_loss improved from 0.72259 to 0.64226, saving model to models\efficintB0_cw_imagenet
INFO:tensorflow:Assets written to: models\efficintB0_cw_imagenet\assets
INFO:tensorflow:Assets written to: models\efficintB0_cw_imagenet\assets
50/50 [==============================] - 132s 3s/step - loss: 0.6625 - acc: 0.7713 - val_loss: 0.6423 - val_acc
: 0.7699
Epoch 10/50
50/50 [==============================] - ETA: 0s - loss: 0.5614 - acc: 0.7982
Epoch 10: val_loss improved from 0.64226 to 0.34639, saving model to models\efficintB0_cw_imagenet
INFO:tensorflow:Assets written to: models\efficintB0_cw_imagenet\assets
INFO:tensorflow:Assets written to: models\efficintB0_cw_imagenet\assets
```

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50/50 [==============================] - 131s 3s/step - loss: 0.5614 - acc: 0.7982 - val_loss: 0.3464 - val_acc
: 0.8734
Epoch 11/50
50/50 [==============================] - ETA: 0s - loss: 0.4982 - acc: 0.8238
Epoch 11: val_loss did not improve from 0.34639
50/50 [==============================] - 120s 2s/step - loss: 0.4982 - acc: 0.8238 - val_loss: 0.6003 - val_acc
: 0.7699
Epoch 12/50
50/50 [==============================] - ETA: 0s - loss: 0.4933 - acc: 0.8253
Epoch 12: val_loss did not improve from 0.34639
50/50 [==============================] - 118s 2s/step - loss: 0.4933 - acc: 0.8253 - val_loss: 0.5269 - val_acc
: 0.7835
Epoch 13/50
50/50 [==============================] - ETA: 0s - loss: 0.4365 - acc: 0.8419
Epoch 13: val_loss did not improve from 0.34639
50/50 [==============================] - 118s 2s/step - loss: 0.4365 - acc: 0.8419 - val_loss: 0.3903 - val_acc
: 0.8609
Epoch 14/50
50/50 [==============================] - ETA: 0s - loss: 0.3857 - acc: 0.8506
Epoch 14: val_loss did not improve from 0.34639
50/50 [==============================] - 118s 2s/step - loss: 0.3857 - acc: 0.8506 - val_loss: 0.8237 - val_acc
: 0.7029
Epoch 15/50
50/50 [==============================] - ETA: 0s - loss: 0.3662 - acc: 0.8632
Epoch 15: val_loss did not improve from 0.34639
50/50 [==============================] - 118s 2s/step - loss: 0.3662 - acc: 0.8632 - val_loss: 0.4099 - val_acc
: 0.8577
Epoch 16/50
50/50 [==============================] - ETA: 0s - loss: 0.3286 - acc: 0.8850
Epoch 16: val_loss improved from 0.34639 to 0.33762, saving model to models\efficintB0_cw_imagenet
INFO:tensorflow:Assets written to: models\efficintB0_cw_imagenet\assets
INFO:tensorflow:Assets written to: models\efficintB0_cw_imagenet\assets
50/50 [==============================] - 134s 3s/step - loss: 0.3286 - acc: 0.8850 - val_loss: 0.3376 - val_acc
: 0.8808
Epoch 17/50
50/50 [==============================] - ETA: 0s - loss: 0.3153 - acc: 0.8758
Epoch 17: val_loss improved from 0.33762 to 0.20352, saving model to models\efficintB0_cw_imagenet
INFO:tensorflow:Assets written to: models\efficintB0_cw_imagenet\assets
INFO:tensorflow:Assets written to: models\efficintB0_cw_imagenet\assets
50/50 [==============================] - 133s 3s/step - loss: 0.3153 - acc: 0.8758 - val_loss: 0.2035 - val_acc
: 0.9268
Epoch 18/50
50/50 [==============================] - ETA: 0s - loss: 0.2895 - acc: 0.8944
Epoch 18: val_loss did not improve from 0.20352
50/50 [==============================] - 115s 2s/step - loss: 0.2895 - acc: 0.8944 - val_loss: 0.2415 - val_acc
: 0.9142
Epoch 19/50
50/50 [==============================] - ETA: 0s - loss: 0.3004 - acc: 0.8888
Epoch 19: val_loss did not improve from 0.20352
50/50 [==============================] - 115s 2s/step - loss: 0.3004 - acc: 0.8888 - val_loss: 0.4898 - val_acc
: 0.8264
Epoch 20/50
50/50 [==============================] - ETA: 0s - loss: 0.2390 - acc: 0.9061
Epoch 20: val_loss improved from 0.20352 to 0.19889, saving model to models\efficintB0_cw_imagenet
INFO:tensorflow:Assets written to: models\efficintB0_cw_imagenet\assets
INFO:tensorflow:Assets written to: models\efficintB0_cw_imagenet\assets
```

```
50/50 [==============================] - 130s 3s/step - loss: 0.2390 - acc: 0.9061 - val_loss: 0.1989 - val_acc
: 0.9236
Epoch 21/50
50/50 [==============================] - ETA: 0s - loss: 0.2616 - acc: 0.9056
Epoch 21: val_loss did not improve from 0.19889
50/50 [==============================] - 119s 2s/step - loss: 0.2616 - acc: 0.9056 - val_loss: 0.4719 - val_acc
: 0.8243
Epoch 22/50
50/50 [==============================] - ETA: 0s - loss: 0.2263 - acc: 0.9130
Epoch 22: val_loss did not improve from 0.19889
50/50 [==============================] - 118s 2s/step - loss: 0.2263 - acc: 0.9130 - val_loss: 0.3423 - val_acc
: 0.8787
Epoch 23/50
50/50 [==============================] - ETA: 0s - loss: 0.2463 - acc: 0.9056
Epoch 23: val_loss did not improve from 0.19889
50/50 [==============================] - 118s 2s/step - loss: 0.2463 - acc: 0.9056 - val_loss: 0.3327 - val_acc
: 0.8849
Epoch 24/50
50/50 [==============================] - ETA: 0s - loss: 0.2452 - acc: 0.8934
Epoch 24: val_loss did not improve from 0.19889
50/50 [==============================] - 118s 2s/step - loss: 0.2452 - acc: 0.8934 - val_loss: 0.3476 - val_acc
: 0.8860
Epoch 25/50
50/50 [==============================] - ETA: 0s - loss: 0.2236 - acc: 0.9081
Epoch 25: val_loss did not improve from 0.19889
50/50 [==============================] - 119s 2s/step - loss: 0.2236 - acc: 0.9081 - val_loss: 0.2721 - val_acc
: 0.8996
Epoch 26/50
50/50 [==============================] - ETA: 0s - loss: 0.2094 - acc: 0.9200
Epoch 26: val_loss did not improve from 0.19889
50/50 [==============================] - 118s 2s/step - loss: 0.2094 - acc: 0.9200 - val_loss: 0.3300 - val_acc

: 0.8870
Epoch 27/50
50/50 [==============================] - ETA: 0s - loss: 0.1950 - acc: 0.9206
Epoch 27: val_loss did not improve from 0.19889
50/50 [==============================] - 117s 2s/step - loss: 0.1950 - acc: 0.9206 - val_loss: 0.5372 - val_acc
: 0.8065
Epoch 28/50
50/50 [==============================] - ETA: 0s - loss: 0.1677 - acc: 0.9306
Epoch 28: val_loss did not improve from 0.19889
50/50 [==============================] - 118s 2s/step - loss: 0.1677 - acc: 0.9306 - val_loss: 0.3425 - val_acc
: 0.8755
Epoch 29/50
50/50 [==============================] - ETA: 0s - loss: 0.1788 - acc: 0.9325
Epoch 29: val_loss did not improve from 0.19889
50/50 [==============================] - 117s 2s/step - loss: 0.1788 - acc: 0.9325 - val_loss: 0.2020 - val_acc
: 0.9320
Epoch 30/50
50/50 [==============================] - ETA: 0s - loss: 0.1815 - acc: 0.9306
Epoch 30: val_loss did not improve from 0.19889
50/50 [==============================] - 117s 2s/step - loss: 0.1815 - acc: 0.9306 - val_loss: 0.2273 - val_acc
: 0.9132
Epoch 30: early stopping
```

Obtenemos métricas para el dataset de validación

In [63]:
```python
# Cargar modelos en memoria
# Cargamos el modelo de prueba
model = load_efficienNetV2(
    num_classes=12,
    imagenet_weights=True)

model.summary()

model.compile(
    loss = tf.keras.losses.categorical_crossentropy,
    optimizer = tf.keras.optimizers.Adam(0.0001),
    metrics = ['acc'])

# Sacar prediccion
model.load_weights("models/efficintB0_cw_imagenet")
prediction = model.predict(valid_tfdataset)
```

```
 > Loading iamgenet weights
Model: "model_9"
```

Layer (type)	Output Shape	Param #	Connected to
input_18 (InputLayer)	[(None, 224, 224, 3)]	0	[]
rescaling_12 (Rescaling)	(None, 224, 224, 3)	0	['input_18[0][0]']
normalization_12 (Normaliz ation)	(None, 224, 224, 3)	0	['rescaling_12[0][0]']
stem_conv (Conv2D)	(None, 112, 112, 32)	864	['normalization_12[0][0]']

```
stem_bn (BatchNormalizatio  (None, 112, 112, 32)         128       ['stem_conv[0][0]']
n)

stem_activation (Activatio  (None, 112, 112, 32)         0         ['stem_bn[0][0]']
n)

block1a_project_conv (Conv  (None, 112, 112, 16)         4608      ['stem_activation[0][0]']
2D)

block1a_project_bn (BatchN  (None, 112, 112, 16)         64        ['block1a_project_conv[0][0]']
ormalization)

block1a_project_activation  (None, 112, 112, 16)         0         ['block1a_project_bn[0][0]']
 (Activation)

block2a_expand_conv (Conv2  (None, 56, 56, 64)           9216      ['block1a_project_activation[0
D)                                                                 ][0]']

block2a_expand_bn (BatchNo  (None, 56, 56, 64)           256       ['block2a_expand_conv[0][0]']
rmalization)

block2a_expand_activation   (None, 56, 56, 64)           0         ['block2a_expand_bn[0][0]']
(Activation)

block2a_project_conv (Conv  (None, 56, 56, 32)           2048      ['block2a_expand_activation[0]
2D)                                                                [0]']

block2a_project_bn (BatchN  (None, 56, 56, 32)           128       ['block2a_project_conv[0][0]']
ormalization)

block2b_expand_conv (Conv2  (None, 56, 56, 128)          36864     ['block2a_project_bn[0][0]']
D)

block2b_expand_bn (BatchNo  (None, 56, 56, 128)          512       ['block2b_expand_conv[0][0]']
rmalization)

block2b_expand_activation   (None, 56, 56, 128)          0         ['block2b_expand_bn[0][0]']
(Activation)

block2b_project_conv (Conv  (None, 56, 56, 32)           4096      ['block2b_expand_activation[0]
2D)                                                                [0]']

block2b_project_bn (BatchN  (None, 56, 56, 32)           128       ['block2b_project_conv[0][0]']
ormalization)

block2b_drop (Dropout)      (None, 56, 56, 32)           0         ['block2b_project_bn[0][0]']

block2b_add (Add)           (None, 56, 56, 32)           0         ['block2b_drop[0][0]',
                                                                   'block2a_project_bn[0][0]']

block3a_expand_conv (Conv2  (None, 28, 28, 128)          36864     ['block2b_add[0][0]']
D)

block3a_expand_bn (BatchNo  (None, 28, 28, 128)          512       ['block3a_expand_conv[0][0]']
rmalization)

block3a_expand_activation   (None, 28, 28, 128)          0         ['block3a_expand_bn[0][0]']
(Activation)

block3a_project_conv (Conv  (None, 28, 28, 48)           6144      ['block3a_expand_activation[0]
2D)                                                                [0]']

block3a_project_bn (BatchN  (None, 28, 28, 48)           192       ['block3a_project_conv[0][0]']
ormalization)

block3b_expand_conv (Conv2  (None, 28, 28, 192)          82944     ['block3a_project_bn[0][0]']
D)

block3b_expand_bn (BatchNo  (None, 28, 28, 192)          768       ['block3b_expand_conv[0][0]']
rmalization)

block3b_expand_activation   (None, 28, 28, 192)          0         ['block3b_expand_bn[0][0]']
(Activation)

block3b_project_conv (Conv  (None, 28, 28, 48)           9216      ['block3b_expand_activation[0]
2D)                                                                [0]']

block3b_project_bn (BatchN  (None, 28, 28, 48)           192       ['block3b_project_conv[0][0]']
ormalization)

block3b_drop (Dropout)      (None, 28, 28, 48)           0         ['block3b_project_bn[0][0]']

block3b_add (Add)           (None, 28, 28, 48)           0         ['block3b_drop[0][0]',
                                                                   'block3a_project_bn[0][0]']

block4a_expand_conv (Conv2  (None, 28, 28, 192)          9216      ['block3b_add[0][0]']
D)

block4a_expand_bn (BatchNo  (None, 28, 28, 192)          768       ['block4a_expand_conv[0][0]']
```

```
rmalization)

block4a_expand_activation   (None, 28, 28, 192)          0         ['block4a_expand_bn[0][0]']
(Activation)

block4a_dwconv2 (Depthwise  (None, 14, 14, 192)          1728      ['block4a_expand_activation[0]
Conv2D)                                                            [0]']

block4a_bn (BatchNormaliza  (None, 14, 14, 192)          768       ['block4a_dwconv2[0][0]']
tion)

block4a_activation (Activa  (None, 14, 14, 192)          0         ['block4a_bn[0][0]']
tion)

block4a_se_squeeze (Global  (None, 192)                  0         ['block4a_activation[0][0]']
AveragePooling2D)

block4a_se_reshape (Reshap  (None, 1, 1, 192)            0         ['block4a_se_squeeze[0][0]']
e)

block4a_se_reduce (Conv2D)  (None, 1, 1, 12)             2316      ['block4a_se_reshape[0][0]']

block4a_se_expand (Conv2D)  (None, 1, 1, 192)            2496      ['block4a_se_reduce[0][0]']

block4a_se_excite (Multipl  (None, 14, 14, 192)          0         ['block4a_activation[0][0]',
y)                                                                 'block4a_se_expand[0][0]']

block4a_project_conv (Conv  (None, 14, 14, 96)           18432     ['block4a_se_excite[0][0]']
2D)

block4a_project_bn (BatchN  (None, 14, 14, 96)           384       ['block4a_project_conv[0][0]']
ormalization)

block4b_expand_conv (Conv2  (None, 14, 14, 384)          36864     ['block4a_project_bn[0][0]']
D)

block4b_expand_bn (BatchNo  (None, 14, 14, 384)          1536      ['block4b_expand_conv[0][0]']
rmalization)

block4b_expand_activation   (None, 14, 14, 384)          0         ['block4b_expand_bn[0][0]']
(Activation)

block4b_dwconv2 (Depthwise  (None, 14, 14, 384)          3456      ['block4b_expand_activation[0]
Conv2D)                                                            [0]']

block4b_bn (BatchNormaliza  (None, 14, 14, 384)          1536      ['block4b_dwconv2[0][0]']
tion)

block4b_activation (Activa  (None, 14, 14, 384)          0         ['block4b_bn[0][0]']
tion)

block4b_se_squeeze (Global  (None, 384)                  0         ['block4b_activation[0][0]']
AveragePooling2D)

block4b_se_reshape (Reshap  (None, 1, 1, 384)            0         ['block4b_se_squeeze[0][0]']
e)

block4b_se_reduce (Conv2D)  (None, 1, 1, 24)             9240      ['block4b_se_reshape[0][0]']

block4b_se_expand (Conv2D)  (None, 1, 1, 384)            9600      ['block4b_se_reduce[0][0]']

block4b_se_excite (Multipl  (None, 14, 14, 384)          0         ['block4b_activation[0][0]',
y)                                                                 'block4b_se_expand[0][0]']

block4b_project_conv (Conv  (None, 14, 14, 96)           36864     ['block4b_se_excite[0][0]']
2D)

block4b_project_bn (BatchN  (None, 14, 14, 96)           384       ['block4b_project_conv[0][0]']
ormalization)

block4b_drop (Dropout)      (None, 14, 14, 96)           0         ['block4b_project_bn[0][0]']

block4b_add (Add)           (None, 14, 14, 96)           0         ['block4b_drop[0][0]',
                                                                   'block4a_project_bn[0][0]']

block4c_expand_conv (Conv2  (None, 14, 14, 384)          36864     ['block4b_add[0][0]']
D)

block4c_expand_bn (BatchNo  (None, 14, 14, 384)          1536      ['block4c_expand_conv[0][0]']
rmalization)

block4c_expand_activation   (None, 14, 14, 384)          0         ['block4c_expand_bn[0][0]']
(Activation)

block4c_dwconv2 (Depthwise  (None, 14, 14, 384)          3456      ['block4c_expand_activation[0]
Conv2D)                                                            [0]']

block4c_bn (BatchNormaliza  (None, 14, 14, 384)          1536      ['block4c_dwconv2[0][0]']
tion)
```

```
block4c_activation (Activa  (None, 14, 14, 384)          0         ['block4c_bn[0][0]']
tion)

block4c_se_squeeze (Global  (None, 384)                  0         ['block4c_activation[0][0]']
AveragePooling2D)

block4c_se_reshape (Reshap  (None, 1, 1, 384)            0         ['block4c_se_squeeze[0][0]']
e)

block4c_se_reduce (Conv2D)  (None, 1, 1, 24)             9240      ['block4c_se_reshape[0][0]']

block4c_se_expand (Conv2D)  (None, 1, 1, 384)            9600      ['block4c_se_reduce[0][0]']

block4c_se_excite (Multipl  (None, 14, 14, 384)          0         ['block4c_activation[0][0]',
y)                                                                  'block4c_se_expand[0][0]']

block4c_project_conv (Conv  (None, 14, 14, 96)           36864     ['block4c_se_excite[0][0]']
2D)

block4c_project_bn (BatchN  (None, 14, 14, 96)           384       ['block4c_project_conv[0][0]']
ormalization)

block4c_drop (Dropout)      (None, 14, 14, 96)           0         ['block4c_project_bn[0][0]']

block4c_add (Add)           (None, 14, 14, 96)           0         ['block4c_drop[0][0]',
                                                                    'block4b_add[0][0]']

block5a_expand_conv (Conv2  (None, 14, 14, 576)          55296     ['block4c_add[0][0]']
D)

block5a_expand_bn (BatchNo  (None, 14, 14, 576)          2304      ['block5a_expand_conv[0][0]']
rmalization)

block5a_expand_activation   (None, 14, 14, 576)          0         ['block5a_expand_bn[0][0]']
(Activation)

block5a_dwconv2 (Depthwise  (None, 14, 14, 576)          5184      ['block5a_expand_activation[0]
Conv2D)                                                             [0]']

block5a_bn (BatchNormaliza  (None, 14, 14, 576)          2304      ['block5a_dwconv2[0][0]']
tion)

block5a_activation (Activa  (None, 14, 14, 576)          0         ['block5a_bn[0][0]']
tion)

block5a_se_squeeze (Global  (None, 576)                  0         ['block5a_activation[0][0]']
AveragePooling2D)

block5a_se_reshape (Reshap  (None, 1, 1, 576)            0         ['block5a_se_squeeze[0][0]']
e)

block5a_se_reduce (Conv2D)  (None, 1, 1, 24)             13848     ['block5a_se_reshape[0][0]']

block5a_se_expand (Conv2D)  (None, 1, 1, 576)            14400     ['block5a_se_reduce[0][0]']

block5a_se_excite (Multipl  (None, 14, 14, 576)          0         ['block5a_activation[0][0]',
y)                                                                  'block5a_se_expand[0][0]']

block5a_project_conv (Conv  (None, 14, 14, 112)          64512     ['block5a_se_excite[0][0]']
2D)

block5a_project_bn (BatchN  (None, 14, 14, 112)          448       ['block5a_project_conv[0][0]']
ormalization)

block5b_expand_conv (Conv2  (None, 14, 14, 672)          75264     ['block5a_project_bn[0][0]']
D)

block5b_expand_bn (BatchNo  (None, 14, 14, 672)          2688      ['block5b_expand_conv[0][0]']
rmalization)

block5b_expand_activation   (None, 14, 14, 672)          0         ['block5b_expand_bn[0][0]']
(Activation)

block5b_dwconv2 (Depthwise  (None, 14, 14, 672)          6048      ['block5b_expand_activation[0]
Conv2D)                                                             [0]']

block5b_bn (BatchNormaliza  (None, 14, 14, 672)          2688      ['block5b_dwconv2[0][0]']
tion)

block5b_activation (Activa  (None, 14, 14, 672)          0         ['block5b_bn[0][0]']
tion)

block5b_se_squeeze (Global  (None, 672)                  0         ['block5b_activation[0][0]']
AveragePooling2D)

block5b_se_reshape (Reshap  (None, 1, 1, 672)            0         ['block5b_se_squeeze[0][0]']
e)
```

```
block5b_se_reduce (Conv2D)  (None, 1, 1, 28)            18844     ['block5b_se_reshape[0][0]']

block5b_se_expand (Conv2D)  (None, 1, 1, 672)           19488     ['block5b_se_reduce[0][0]']

block5b_se_excite (Multipl  (None, 14, 14, 672)         0         ['block5b_activation[0][0]',
y)                                                                  'block5b_se_expand[0][0]']

block5b_project_conv (Conv  (None, 14, 14, 112)         75264     ['block5b_se_excite[0][0]']
2D)

block5b_project_bn (BatchN  (None, 14, 14, 112)         448       ['block5b_project_conv[0][0]']
ormalization)

block5b_drop (Dropout)      (None, 14, 14, 112)         0         ['block5b_project_bn[0][0]']

block5b_add (Add)           (None, 14, 14, 112)         0         ['block5b_drop[0][0]',
                                                                    'block5a_project_bn[0][0]']

block5c_expand_conv (Conv2  (None, 14, 14, 672)         75264     ['block5b_add[0][0]']
D)

block5c_expand_bn (BatchNo  (None, 14, 14, 672)         2688      ['block5c_expand_conv[0][0]']
rmalization)

block5c_expand_activation   (None, 14, 14, 672)         0         ['block5c_expand_bn[0][0]']
(Activation)

block5c_dwconv2 (Depthwise  (None, 14, 14, 672)         6048      ['block5c_expand_activation[0]
Conv2D)                                                           [0]']

block5c_bn (BatchNormaliza  (None, 14, 14, 672)         2688      ['block5c_dwconv2[0][0]']
tion)

block5c_activation (Activa  (None, 14, 14, 672)         0         ['block5c_bn[0][0]']
tion)

block5c_se_squeeze (Global  (None, 672)                 0         ['block5c_activation[0][0]']
AveragePooling2D)

block5c_se_reshape (Reshap  (None, 1, 1, 672)           0         ['block5c_se_squeeze[0][0]']
e)

block5c_se_reduce (Conv2D)  (None, 1, 1, 28)            18844     ['block5c_se_reshape[0][0]']

block5c_se_expand (Conv2D)  (None, 1, 1, 672)           19488     ['block5c_se_reduce[0][0]']

block5c_se_excite (Multipl  (None, 14, 14, 672)         0         ['block5c_activation[0][0]',
y)                                                                  'block5c_se_expand[0][0]']

block5c_project_conv (Conv  (None, 14, 14, 112)         75264     ['block5c_se_excite[0][0]']
2D)

block5c_project_bn (BatchN  (None, 14, 14, 112)         448       ['block5c_project_conv[0][0]']
ormalization)

block5c_drop (Dropout)      (None, 14, 14, 112)         0         ['block5c_project_bn[0][0]']

block5c_add (Add)           (None, 14, 14, 112)         0         ['block5c_drop[0][0]',
                                                                    'block5b_add[0][0]']

block5d_expand_conv (Conv2  (None, 14, 14, 672)         75264     ['block5c_add[0][0]']
D)

block5d_expand_bn (BatchNo  (None, 14, 14, 672)         2688      ['block5d_expand_conv[0][0]']
rmalization)

block5d_expand_activation   (None, 14, 14, 672)         0         ['block5d_expand_bn[0][0]']
(Activation)

block5d_dwconv2 (Depthwise  (None, 14, 14, 672)         6048      ['block5d_expand_activation[0]
Conv2D)                                                           [0]']

block5d_bn (BatchNormaliza  (None, 14, 14, 672)         2688      ['block5d_dwconv2[0][0]']
tion)

block5d_activation (Activa  (None, 14, 14, 672)         0         ['block5d_bn[0][0]']
tion)

block5d_se_squeeze (Global  (None, 672)                 0         ['block5d_activation[0][0]']
AveragePooling2D)

block5d_se_reshape (Reshap  (None, 1, 1, 672)           0         ['block5d_se_squeeze[0][0]']
e)

block5d_se_reduce (Conv2D)  (None, 1, 1, 28)            18844     ['block5d_se_reshape[0][0]']

block5d_se_expand (Conv2D)  (None, 1, 1, 672)           19488     ['block5d_se_reduce[0][0]']

block5d_se_excite (Multipl  (None, 14, 14, 672)         0         ['block5d_activation[0][0]',
```

```
y)                                                                 'block5d_se_expand[0][0]']

block5d_project_conv (Conv  (None, 14, 14, 112)          75264     ['block5d_se_excite[0][0]']
2D)

block5d_project_bn (BatchN  (None, 14, 14, 112)          448       ['block5d_project_conv[0][0]']
ormalization)

block5d_drop (Dropout)      (None, 14, 14, 112)          0         ['block5d_project_bn[0][0]']

block5d_add (Add)           (None, 14, 14, 112)          0         ['block5d_drop[0][0]',
                                                                    'block5c_add[0][0]']

block5e_expand_conv (Conv2  (None, 14, 14, 672)          75264     ['block5d_add[0][0]']
D)

block5e_expand_bn (BatchNo  (None, 14, 14, 672)          2688      ['block5e_expand_conv[0][0]']
rmalization)

block5e_expand_activation   (None, 14, 14, 672)          0         ['block5e_expand_bn[0][0]']
(Activation)

block5e_dwconv2 (Depthwise  (None, 14, 14, 672)          6048      ['block5e_expand_activation[0]
Conv2D)                                                            [0]']

block5e_bn (BatchNormaliza  (None, 14, 14, 672)          2688      ['block5e_dwconv2[0][0]']
tion)

block5e_activation (Activa  (None, 14, 14, 672)          0         ['block5e_bn[0][0]']
tion)

block5e_se_squeeze (Global  (None, 672)                  0         ['block5e_activation[0][0]']
AveragePooling2D)

block5e_se_reshape (Reshap  (None, 1, 1, 672)            0         ['block5e_se_squeeze[0][0]']
e)

block5e_se_reduce (Conv2D)  (None, 1, 1, 28)             18844     ['block5e_se_reshape[0][0]']

block5e_se_expand (Conv2D)  (None, 1, 1, 672)            19488     ['block5e_se_reduce[0][0]']

block5e_se_excite (Multipl  (None, 14, 14, 672)          0         ['block5e_activation[0][0]',
y)                                                                  'block5e_se_expand[0][0]']

block5e_project_conv (Conv  (None, 14, 14, 112)          75264     ['block5e_se_excite[0][0]']
2D)

block5e_project_bn (BatchN  (None, 14, 14, 112)          448       ['block5e_project_conv[0][0]']
ormalization)

block5e_drop (Dropout)      (None, 14, 14, 112)          0         ['block5e_project_bn[0][0]']

block5e_add (Add)           (None, 14, 14, 112)          0         ['block5e_drop[0][0]',
                                                                    'block5d_add[0][0]']

block6a_expand_conv (Conv2  (None, 14, 14, 672)          75264     ['block5e_add[0][0]']
D)

block6a_expand_bn (BatchNo  (None, 14, 14, 672)          2688      ['block6a_expand_conv[0][0]']
rmalization)

block6a_expand_activation   (None, 14, 14, 672)          0         ['block6a_expand_bn[0][0]']
(Activation)

block6a_dwconv2 (Depthwise  (None, 7, 7, 672)            6048      ['block6a_expand_activation[0]
Conv2D)                                                            [0]']

block6a_bn (BatchNormaliza  (None, 7, 7, 672)            2688      ['block6a_dwconv2[0][0]']
tion)

block6a_activation (Activa  (None, 7, 7, 672)            0         ['block6a_bn[0][0]']
tion)

block6a_se_squeeze (Global  (None, 672)                  0         ['block6a_activation[0][0]']
AveragePooling2D)

block6a_se_reshape (Reshap  (None, 1, 1, 672)            0         ['block6a_se_squeeze[0][0]']
e)

block6a_se_reduce (Conv2D)  (None, 1, 1, 28)             18844     ['block6a_se_reshape[0][0]']

block6a_se_expand (Conv2D)  (None, 1, 1, 672)            19488     ['block6a_se_reduce[0][0]']

block6a_se_excite (Multipl  (None, 7, 7, 672)            0         ['block6a_activation[0][0]',
y)                                                                  'block6a_se_expand[0][0]']

block6a_project_conv (Conv  (None, 7, 7, 192)            129024    ['block6a_se_excite[0][0]']
2D)
```

```
block6a_project_bn (BatchN  (None, 7, 7, 192)           768       ['block6a_project_conv[0][0]']
ormalization)

block6b_expand_conv (Conv2  (None, 7, 7, 1152)          221184    ['block6a_project_bn[0][0]']
D)

block6b_expand_bn (BatchNo  (None, 7, 7, 1152)          4608      ['block6b_expand_conv[0][0]']
rmalization)

block6b_expand_activation   (None, 7, 7, 1152)          0         ['block6b_expand_bn[0][0]']
(Activation)

block6b_dwconv2 (Depthwise  (None, 7, 7, 1152)          10368     ['block6b_expand_activation[0]
Conv2D)                                                           [0]']

block6b_bn (BatchNormaliza  (None, 7, 7, 1152)          4608      ['block6b_dwconv2[0][0]']
tion)

block6b_activation (Activa  (None, 7, 7, 1152)          0         ['block6b_bn[0][0]']
tion)

block6b_se_squeeze (Global  (None, 1152)                0         ['block6b_activation[0][0]']
AveragePooling2D)

block6b_se_reshape (Reshap  (None, 1, 1, 1152)          0         ['block6b_se_squeeze[0][0]']
e)

block6b_se_reduce (Conv2D)  (None, 1, 1, 48)            55344     ['block6b_se_reshape[0][0]']

block6b_se_expand (Conv2D)  (None, 1, 1, 1152)          56448     ['block6b_se_reduce[0][0]']

block6b_se_excite (Multipl  (None, 7, 7, 1152)          0         ['block6b_activation[0][0]',
y)                                                                 'block6b_se_expand[0][0]']

block6b_project_conv (Conv  (None, 7, 7, 192)           221184    ['block6b_se_excite[0][0]']
2D)

block6b_project_bn (BatchN  (None, 7, 7, 192)           768       ['block6b_project_conv[0][0]']
ormalization)

block6b_drop (Dropout)      (None, 7, 7, 192)           0         ['block6b_project_bn[0][0]']

block6b_add (Add)           (None, 7, 7, 192)           0         ['block6b_drop[0][0]',
                                                                   'block6a_project_bn[0][0]']

block6c_expand_conv (Conv2  (None, 7, 7, 1152)          221184    ['block6b_add[0][0]']
D)

block6c_expand_bn (BatchNo  (None, 7, 7, 1152)          4608      ['block6c_expand_conv[0][0]']
rmalization)

block6c_expand_activation   (None, 7, 7, 1152)          0         ['block6c_expand_bn[0][0]']
(Activation)

block6c_dwconv2 (Depthwise  (None, 7, 7, 1152)          10368     ['block6c_expand_activation[0]
Conv2D)                                                           [0]']

block6c_bn (BatchNormaliza  (None, 7, 7, 1152)          4608      ['block6c_dwconv2[0][0]']
tion)

block6c_activation (Activa  (None, 7, 7, 1152)          0         ['block6c_bn[0][0]']
tion)

block6c_se_squeeze (Global  (None, 1152)                0         ['block6c_activation[0][0]']
AveragePooling2D)

block6c_se_reshape (Reshap  (None, 1, 1, 1152)          0         ['block6c_se_squeeze[0][0]']
e)

block6c_se_reduce (Conv2D)  (None, 1, 1, 48)            55344     ['block6c_se_reshape[0][0]']

block6c_se_expand (Conv2D)  (None, 1, 1, 1152)          56448     ['block6c_se_reduce[0][0]']

block6c_se_excite (Multipl  (None, 7, 7, 1152)          0         ['block6c_activation[0][0]',
y)                                                                 'block6c_se_expand[0][0]']

block6c_project_conv (Conv  (None, 7, 7, 192)           221184    ['block6c_se_excite[0][0]']
2D)

block6c_project_bn (BatchN  (None, 7, 7, 192)           768       ['block6c_project_conv[0][0]']
ormalization)

block6c_drop (Dropout)      (None, 7, 7, 192)           0         ['block6c_project_bn[0][0]']

block6c_add (Add)           (None, 7, 7, 192)           0         ['block6c_drop[0][0]',
                                                                   'block6b_add[0][0]']

block6d_expand_conv (Conv2  (None, 7, 7, 1152)          221184    ['block6c_add[0][0]']
D)
```

```
block6d_expand_bn (BatchNo  (None, 7, 7, 1152)          4608      ['block6d_expand_conv[0][0]']
rmalization)

block6d_expand_activation   (None, 7, 7, 1152)          0         ['block6d_expand_bn[0][0]']
(Activation)

block6d_dwconv2 (Depthwise  (None, 7, 7, 1152)          10368     ['block6d_expand_activation[0]
Conv2D)                                                           [0]']

block6d_bn (BatchNormaliza  (None, 7, 7, 1152)          4608      ['block6d_dwconv2[0][0]']
tion)

block6d_activation (Activa  (None, 7, 7, 1152)          0         ['block6d_bn[0][0]']
tion)

block6d_se_squeeze (Global  (None, 1152)                0         ['block6d_activation[0][0]']
AveragePooling2D)

block6d_se_reshape (Reshap  (None, 1, 1, 1152)          0         ['block6d_se_squeeze[0][0]']
e)

block6d_se_reduce (Conv2D)  (None, 1, 1, 48)            55344     ['block6d_se_reshape[0][0]']

block6d_se_expand (Conv2D)  (None, 1, 1, 1152)          56448     ['block6d_se_reduce[0][0]']

block6d_se_excite (Multipl  (None, 7, 7, 1152)          0         ['block6d_activation[0][0]',
y)                                                                 'block6d_se_expand[0][0]']

block6d_project_conv (Conv  (None, 7, 7, 192)           221184    ['block6d_se_excite[0][0]']
2D)

block6d_project_bn (BatchN  (None, 7, 7, 192)           768       ['block6d_project_conv[0][0]']
ormalization)

block6d_drop (Dropout)      (None, 7, 7, 192)           0         ['block6d_project_bn[0][0]']

block6d_add (Add)           (None, 7, 7, 192)           0         ['block6d_drop[0][0]',
                                                                   'block6c_add[0][0]']

block6e_expand_conv (Conv2  (None, 7, 7, 1152)          221184    ['block6d_add[0][0]']
D)

block6e_expand_bn (BatchNo  (None, 7, 7, 1152)          4608      ['block6e_expand_conv[0][0]']
rmalization)

block6e_expand_activation   (None, 7, 7, 1152)          0         ['block6e_expand_bn[0][0]']
(Activation)

block6e_dwconv2 (Depthwise  (None, 7, 7, 1152)          10368     ['block6e_expand_activation[0]
Conv2D)                                                           [0]']

block6e_bn (BatchNormaliza  (None, 7, 7, 1152)          4608      ['block6e_dwconv2[0][0]']
tion)

block6e_activation (Activa  (None, 7, 7, 1152)          0         ['block6e_bn[0][0]']
tion)

block6e_se_squeeze (Global  (None, 1152)                0         ['block6e_activation[0][0]']
AveragePooling2D)

block6e_se_reshape (Reshap  (None, 1, 1, 1152)          0         ['block6e_se_squeeze[0][0]']
e)

block6e_se_reduce (Conv2D)  (None, 1, 1, 48)            55344     ['block6e_se_reshape[0][0]']

block6e_se_expand (Conv2D)  (None, 1, 1, 1152)          56448     ['block6e_se_reduce[0][0]']

block6e_se_excite (Multipl  (None, 7, 7, 1152)          0         ['block6e_activation[0][0]',
y)                                                                 'block6e_se_expand[0][0]']

block6e_project_conv (Conv  (None, 7, 7, 192)           221184    ['block6e_se_excite[0][0]']
2D)

block6e_project_bn (BatchN  (None, 7, 7, 192)           768       ['block6e_project_conv[0][0]']
ormalization)

block6e_drop (Dropout)      (None, 7, 7, 192)           0         ['block6e_project_bn[0][0]']

block6e_add (Add)           (None, 7, 7, 192)           0         ['block6e_drop[0][0]',
                                                                   'block6d_add[0][0]']

block6f_expand_conv (Conv2  (None, 7, 7, 1152)          221184    ['block6e_add[0][0]']
D)

block6f_expand_bn (BatchNo  (None, 7, 7, 1152)          4608      ['block6f_expand_conv[0][0]']
rmalization)

block6f_expand_activation   (None, 7, 7, 1152)          0         ['block6f_expand_bn[0][0]']
```

```
(Activation)

block6f_dwconv2 (Depthwise  (None, 7, 7, 1152)          10368     ['block6f_expand_activation[0]
Conv2D)                                                           [0]']

block6f_bn (BatchNormaliza  (None, 7, 7, 1152)          4608      ['block6f_dwconv2[0][0]']
tion)

block6f_activation (Activa  (None, 7, 7, 1152)          0         ['block6f_bn[0][0]']
tion)

block6f_se_squeeze (Global  (None, 1152)                0         ['block6f_activation[0][0]']
AveragePooling2D)

block6f_se_reshape (Reshap  (None, 1, 1, 1152)          0         ['block6f_se_squeeze[0][0]']
e)

block6f_se_reduce (Conv2D)  (None, 1, 1, 48)            55344     ['block6f_se_reshape[0][0]']

block6f_se_expand (Conv2D)  (None, 1, 1, 1152)          56448     ['block6f_se_reduce[0][0]']

block6f_se_excite (Multipl  (None, 7, 7, 1152)          0         ['block6f_activation[0][0]',
y)                                                                 'block6f_se_expand[0][0]']

block6f_project_conv (Conv  (None, 7, 7, 192)           221184    ['block6f_se_excite[0][0]']
2D)

block6f_project_bn (BatchN  (None, 7, 7, 192)           768       ['block6f_project_conv[0][0]']
ormalization)

block6f_drop (Dropout)      (None, 7, 7, 192)           0         ['block6f_project_bn[0][0]']

block6f_add (Add)           (None, 7, 7, 192)           0         ['block6f_drop[0][0]',
                                                                   'block6e_add[0][0]']

block6g_expand_conv (Conv2  (None, 7, 7, 1152)          221184    ['block6f_add[0][0]']
D)

block6g_expand_bn (BatchNo  (None, 7, 7, 1152)          4608      ['block6g_expand_conv[0][0]']
rmalization)

block6g_expand_activation   (None, 7, 7, 1152)          0         ['block6g_expand_bn[0][0]']
(Activation)

block6g_dwconv2 (Depthwise  (None, 7, 7, 1152)          10368     ['block6g_expand_activation[0]
Conv2D)                                                           [0]']

block6g_bn (BatchNormaliza  (None, 7, 7, 1152)          4608      ['block6g_dwconv2[0][0]']
tion)

block6g_activation (Activa  (None, 7, 7, 1152)          0         ['block6g_bn[0][0]']
tion)

block6g_se_squeeze (Global  (None, 1152)                0         ['block6g_activation[0][0]']
AveragePooling2D)

block6g_se_reshape (Reshap  (None, 1, 1, 1152)          0         ['block6g_se_squeeze[0][0]']
e)

block6g_se_reduce (Conv2D)  (None, 1, 1, 48)            55344     ['block6g_se_reshape[0][0]']

block6g_se_expand (Conv2D)  (None, 1, 1, 1152)          56448     ['block6g_se_reduce[0][0]']

block6g_se_excite (Multipl  (None, 7, 7, 1152)          0         ['block6g_activation[0][0]',
y)                                                                 'block6g_se_expand[0][0]']

block6g_project_conv (Conv  (None, 7, 7, 192)           221184    ['block6g_se_excite[0][0]']
2D)

block6g_project_bn (BatchN  (None, 7, 7, 192)           768       ['block6g_project_conv[0][0]']
ormalization)

block6g_drop (Dropout)      (None, 7, 7, 192)           0         ['block6g_project_bn[0][0]']

block6g_add (Add)           (None, 7, 7, 192)           0         ['block6g_drop[0][0]',
                                                                   'block6f_add[0][0]']

block6h_expand_conv (Conv2  (None, 7, 7, 1152)          221184    ['block6g_add[0][0]']
D)

block6h_expand_bn (BatchNo  (None, 7, 7, 1152)          4608      ['block6h_expand_conv[0][0]']
rmalization)

block6h_expand_activation   (None, 7, 7, 1152)          0         ['block6h_expand_bn[0][0]']
(Activation)

block6h_dwconv2 (Depthwise  (None, 7, 7, 1152)          10368     ['block6h_expand_activation[0]
Conv2D)                                                           [0]']
```

```
block6h_bn (BatchNormaliza  (None, 7, 7, 1152)          4608      ['block6h_dwconv2[0][0]']
tion)

block6h_activation (Activa  (None, 7, 7, 1152)          0         ['block6h_bn[0][0]']
tion)

block6h_se_squeeze (Global  (None, 1152)                0         ['block6h_activation[0][0]']
AveragePooling2D)

block6h_se_reshape (Reshap  (None, 1, 1, 1152)          0         ['block6h_se_squeeze[0][0]']
e)

block6h_se_reduce (Conv2D)  (None, 1, 1, 48)            55344     ['block6h_se_reshape[0][0]']

block6h_se_expand (Conv2D)  (None, 1, 1, 1152)          56448     ['block6h_se_reduce[0][0]']

block6h_se_excite (Multipl  (None, 7, 7, 1152)          0         ['block6h_activation[0][0]',
y)                                                                  'block6h_se_expand[0][0]']

block6h_project_conv (Conv  (None, 7, 7, 192)           221184    ['block6h_se_excite[0][0]']
2D)

block6h_project_bn (BatchN  (None, 7, 7, 192)           768       ['block6h_project_conv[0][0]']
ormalization)

block6h_drop (Dropout)      (None, 7, 7, 192)           0         ['block6h_project_bn[0][0]']

block6h_add (Add)           (None, 7, 7, 192)           0         ['block6h_drop[0][0]',
                                                                    'block6g_add[0][0]']

top_conv (Conv2D)           (None, 7, 7, 1280)          245760    ['block6h_add[0][0]']

top_bn (BatchNormalization  (None, 7, 7, 1280)          5120      ['top_conv[0][0]']
)

top_activation (Activation  (None, 7, 7, 1280)          0         ['top_bn[0][0]']
)

global_average_pooling2d_1  (None, 1280)                0         ['top_activation[0][0]']
1 (GlobalAveragePooling2D)

global_max_pooling2d_10 (G  (None, 1280)                0         ['top_activation[0][0]']
lobalMaxPooling2D)

concatenate_9 (Concatenate  (None, 2560)                0         ['global_average_pooling2d_11[
)                                                                  0][0]',
                                                                    'global_max_pooling2d_10[0][0
                                                                   ]']

dropout_45 (Dropout)        (None, 2560)                0         ['concatenate_9[0][0]']

dense_19 (Dense)            (None, 12)                  30732     ['dropout_45[0][0]']

==================================================================================================
Total params: 5950044 (22.70 MB)
Trainable params: 5889436 (22.47 MB)
Non-trainable params: 60608 (236.75 KB)
__________________________________________________________________________________________________
2023-11-26 20:33:15.205783: W tensorflow/core/util/tensor_slice_reader.cc:98] Could not open models/efficintB0_cw_imagenet: FAILED_PRECONDITION: models/efficintB0_cw_imagenet; Is a directory: perhaps your file is in a different file format and you need to use a different restore operator?
30/30 [==============================] - 6s 155ms/step
```

In [64]:
```
# Mostrar classification report
print("Classification Report EfficientNetV2 B0 (ImageNet Weights)")
print_classification_report(df_dataset_valid["label"].to_numpy(), prediction)
```

```
Classification Report EfficientNetV2 B0 (ImageNet Weights)
Classification Report:
              precision    recall  f1-score   support

           0       0.88      0.79      0.83       131
           1       1.00      0.98      0.99       123
           2       0.95      0.98      0.97       104
           3       1.00      0.99      0.99       100
           4       0.95      0.95      0.95        95
           5       0.96      0.97      0.97        78
           6       0.95      0.95      0.95        77
           7       1.00      0.93      0.96        58
           8       0.52      0.60      0.56        53
           9       0.96      0.98      0.97        47
          10       0.81      0.96      0.88        45
          11       0.98      1.00      0.99        45

    accuracy                           0.92       956
   macro avg       0.91      0.92      0.92       956
weighted avg       0.93      0.92      0.92       956
```

6.1 Evaluación del modelo predictivo y planteamiento de la siguiente prueba experimental (from scratch)

Estrategia 1: Entrenar desde cero o from scratch

Para realizar esta parte de la práctica se han utilizado un total de 6 arquitecturas diferentes. Para hacer experimentos comparativos y poder ver cómo afectan las técnicas de regularización a las arquitecturas, todas tienen el mismo top model para hacer la clasificación y comparten algunos métodos de regularización que se mantienen a lo largo de todas las arquitecturas.

Se definen ciertos parámetros comunes en todos los experimentos:

Hiperparámetros de entrenamiento:

- Paso por época: 32
- Épocas: 50

Top model:

- Capa densa de 128 unidades y activación ReLU
- Capa de salida con activación softmax para la clasificación multiclase

Class Weights:

El dataset tiene un desequilibrio elevado en las clases y por lo tanto, se puede producir un sesgo en el entrenamiento. Para poder evitarlo, se ha aplicado a cada entrenamiento el parámetro "class_weights" de SkLearn. Al hacer esto, se le aplican diferentes pesos a las clases en la función de pérdidas durante el entrenamiento.

A continuación, se describen las arquitecturas utilizadas junto con su nombre:

Model1:

Capas convolucionales:

- Block 1: 64 filtros, kernel 3x3, Maxpooling 2x2, Batch Normalization, Dropout (0.1)
- Block 2: 128 filtros, kernel 3x3, Maxpooling 2x2, Batch Normalization, Dropout (0.1)
- Block 3: 256 filtros, kernel 3x3, Maxpooling 2x2, Batch Normalization, Dropout (0.1)

Técnicas de regularización:

- Uso de Dropout y Batch Normalization en todas las capas convolucionales

Model1_nobatchnorm:

Capas convolucionales:

- Block 1: 64 filtros, kernel 3x3, Maxpooling 2x2, Dropout (0.1)
- Block 2: 128 filtros, kernel 3x3, Maxpooling 2x2, Dropout (0.1)
- Block 3: 256 filtros, kernel 3x3, Maxpooling 2x2, Dropout (0.1)

Técnicas de regularización:

- Uso de Dropout en todas las capas convolucionales

Model2:

Capas convolucionales:

- Block 1: 64 filtros, kernel 5x5, Maxpooling 2x2, Batch Normalization, Dropout (0.1)
- Block 2: 128 filtros, kernel 5x5, Maxpooling 2x2, Batch Normalization, Dropout (0.1)

Técnicas de regularización:

- Uso de Dropout y Batch Normalization en todas las capas convolucionales

Model2_nobatchnorm:

Capas convolucionales:

- Block 1: 64 filtros, kernel 5x5, Maxpooling 2x2, Dropout (0.1)

- Block 2: 128 filtros, kernel 5x5, Maxpooling 2x2, Dropout (0.1)

Técnicas de regularización:

- Uso de Dropout en todas las capas convolucionales

Model3:

Capas convolucionales:

- Block 1: 64 filtros, kernel 3x3, Maxpooling 2x2, Batch Normalization, Dropout (0.1)
- Block 2: 128 filtros, kernel 3x3, Maxpooling 2x2, Batch Normalization, Dropout (0.1)
- Block 3: 256 filtros, kernel 3x3, Maxpooling 2x2, Batch Normalization, Dropout (0.1)
- Block 4: 512 filtros, kernel 3x3, Maxpooling 2x2, Batch Normalization, Dropout (0.1)

Técnicas de regularización:

- Uso de Dropout y Batch Normalization en todas las capas convolucionales

Model3_nobatchnorm:

Capas convolucionales:

- Block 1: 64 filtros, kernel 3x3, Maxpooling 2x2, Dropout (0.1)
- Block 2: 128 filtros, kernel 3x3, Maxpooling 2x2, Dropout (0.1)
- Block 3: 256 filtros, kernel 3x3, Maxpooling 2x2, Dropout (0.1)
- Block 4: 512 filtros, kernel 3x3, Maxpooling 2x2, Dropout (0.1)

Técnicas de regularización:

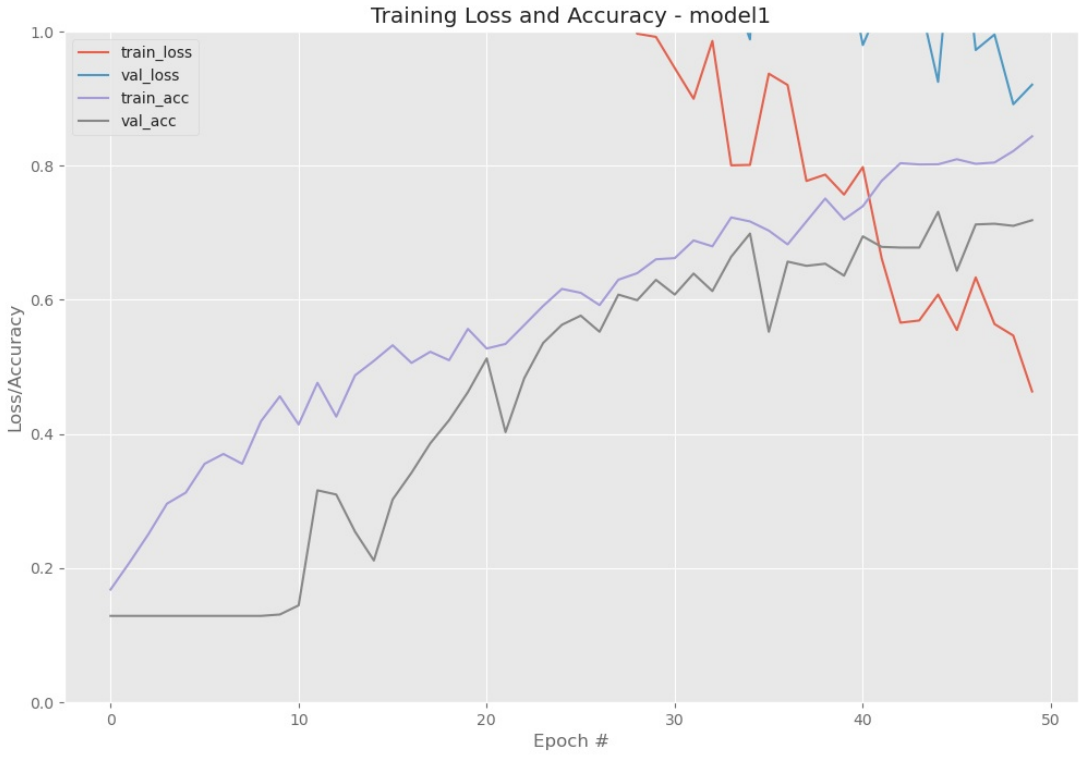
- Uso de Dropout en todas las capas convolucionales

Análisis de resultados:

Se puede observar que el Model3 con Batch Normalization tiene unas métricas mejores que el resto de modelos. Esto se puede deber tanto a la propia regularización de la red como al hecho de que tiene más número de parámetros. Al no tener un dataset de test con etiquetas, no podemos comprobar la fiabilidad de las métricas fuera del entrenamiento.

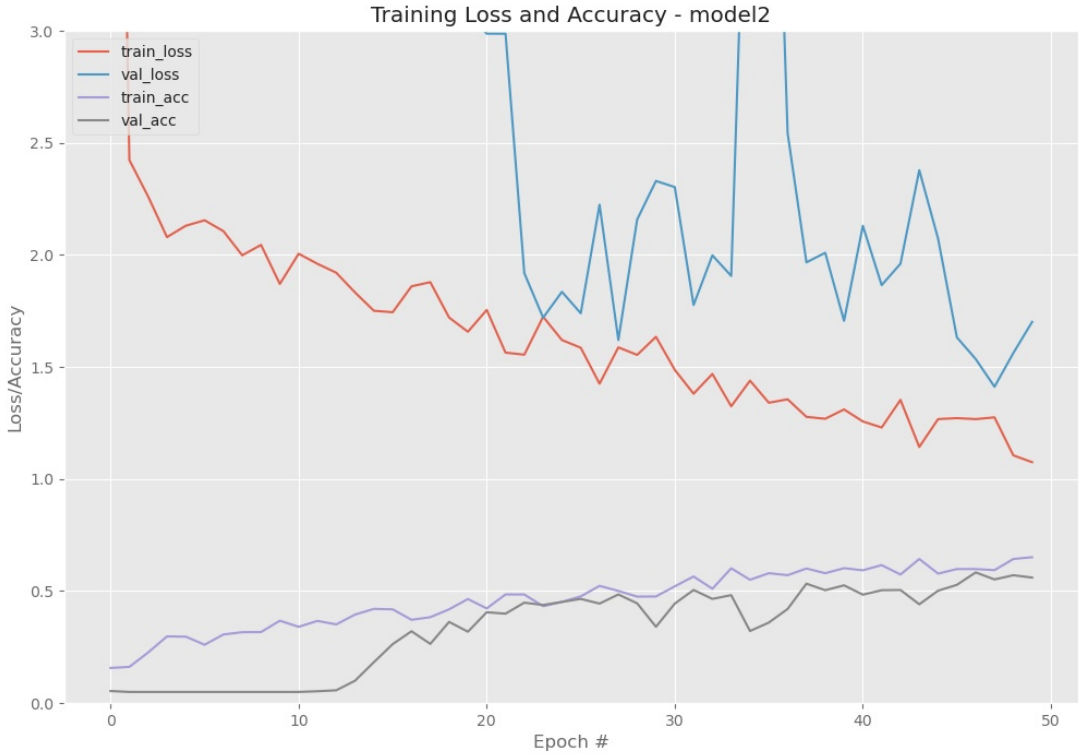
A continuación, se muestran las gráficas de entrenamiento para cada modelo:

Model1:

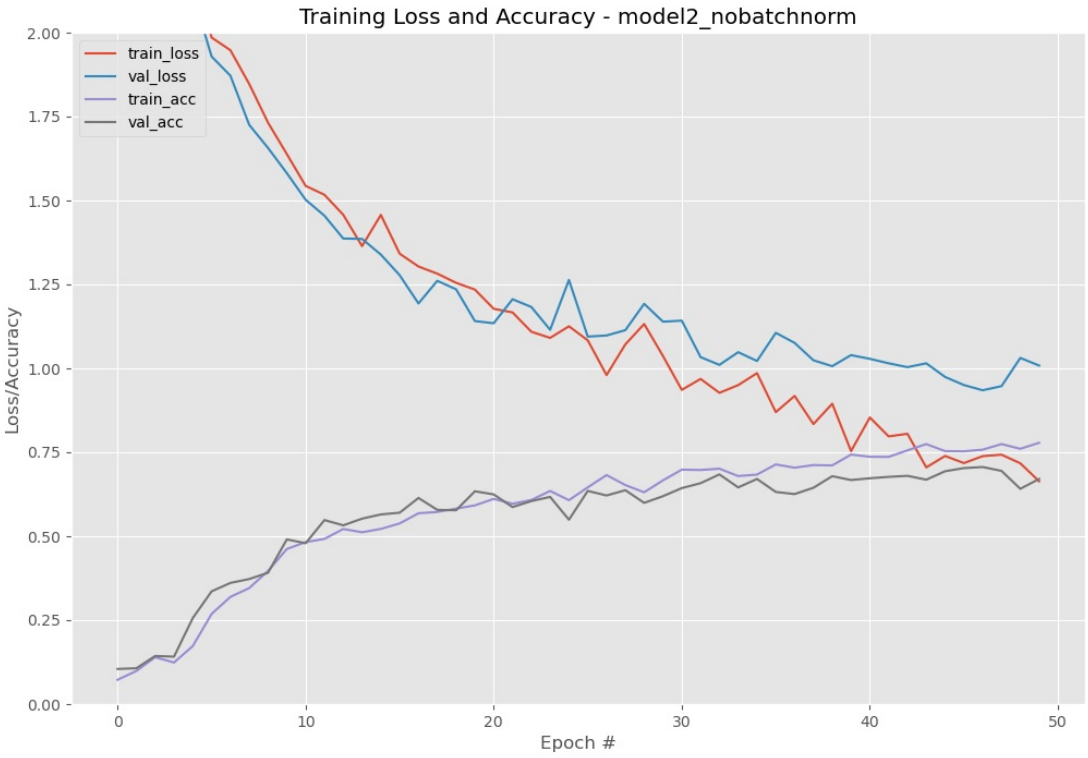


Model1 No Batch Normalization:

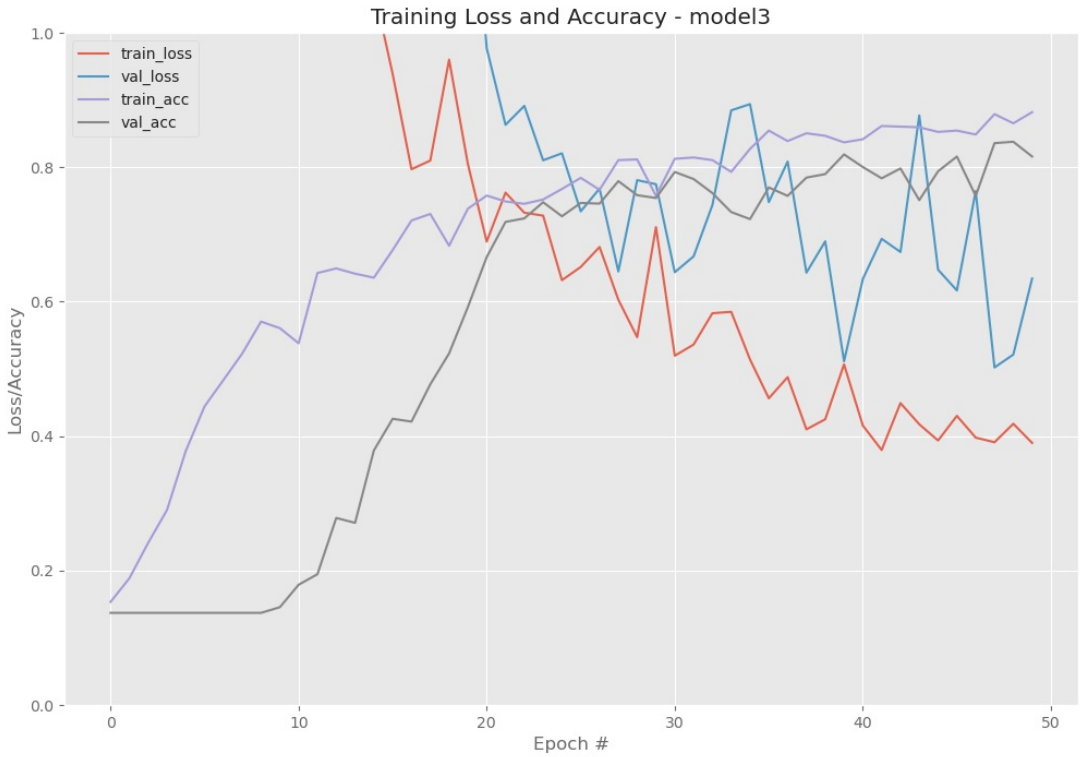
Model2:



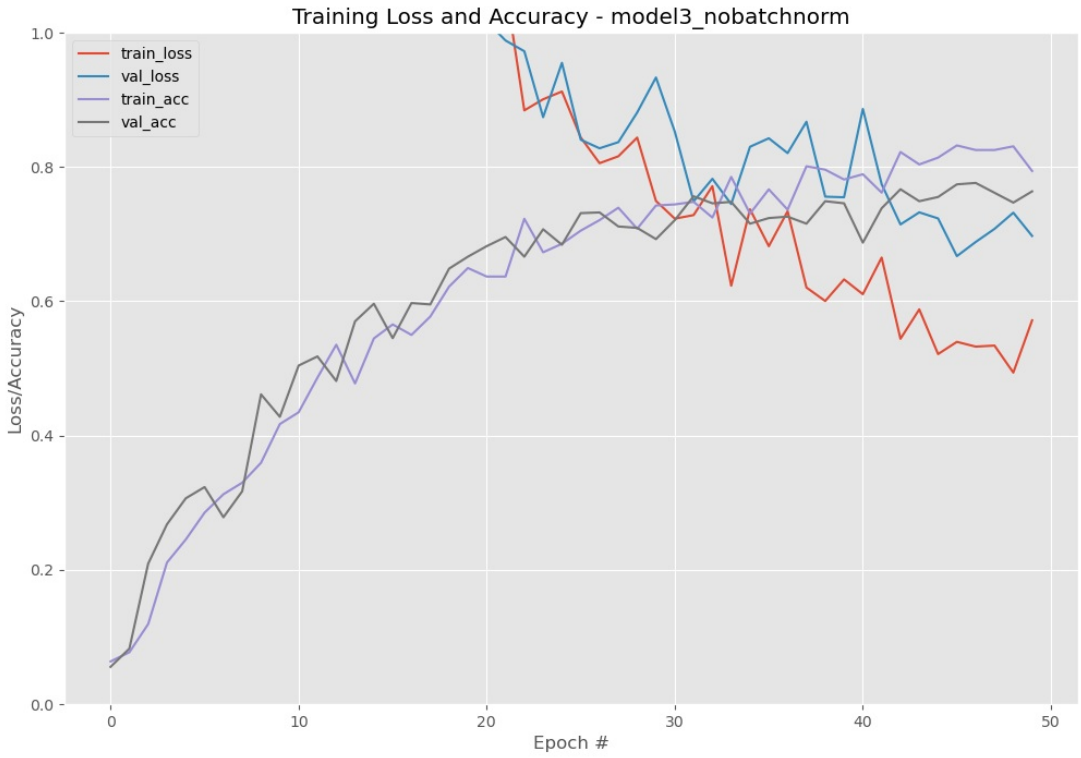
Model2 No Batch Normalization:



Model3:



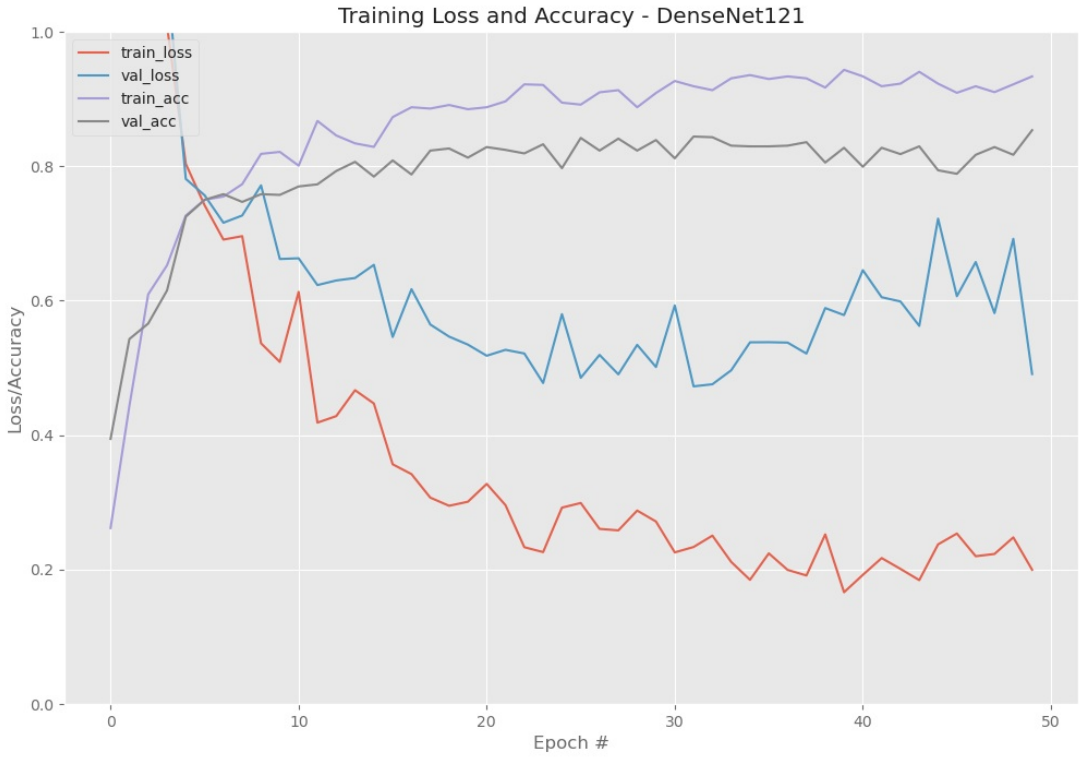
Model3 No Batch Normalization:



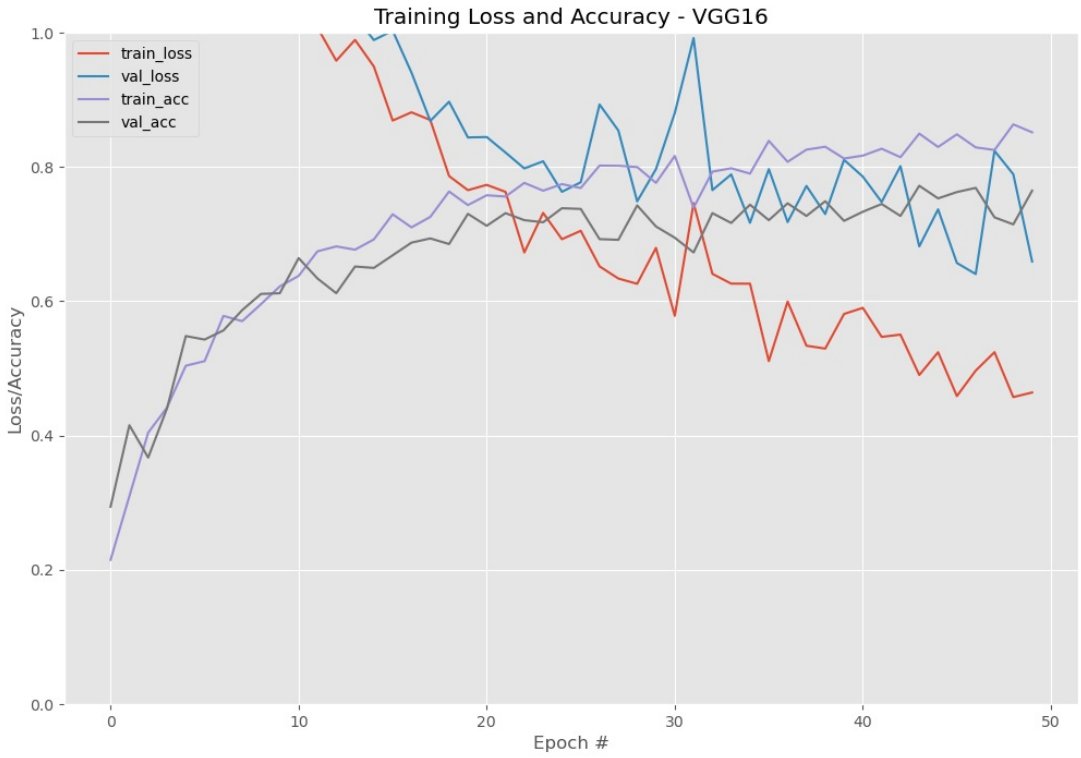
6.2 Evaluación del modelo predictivo y planteamiento de la siguiente prueba experimental (pre-entrenada)

Para realizar una comparación de los modelos vamos a observar las curvas de la función de pérdida y la precisión.

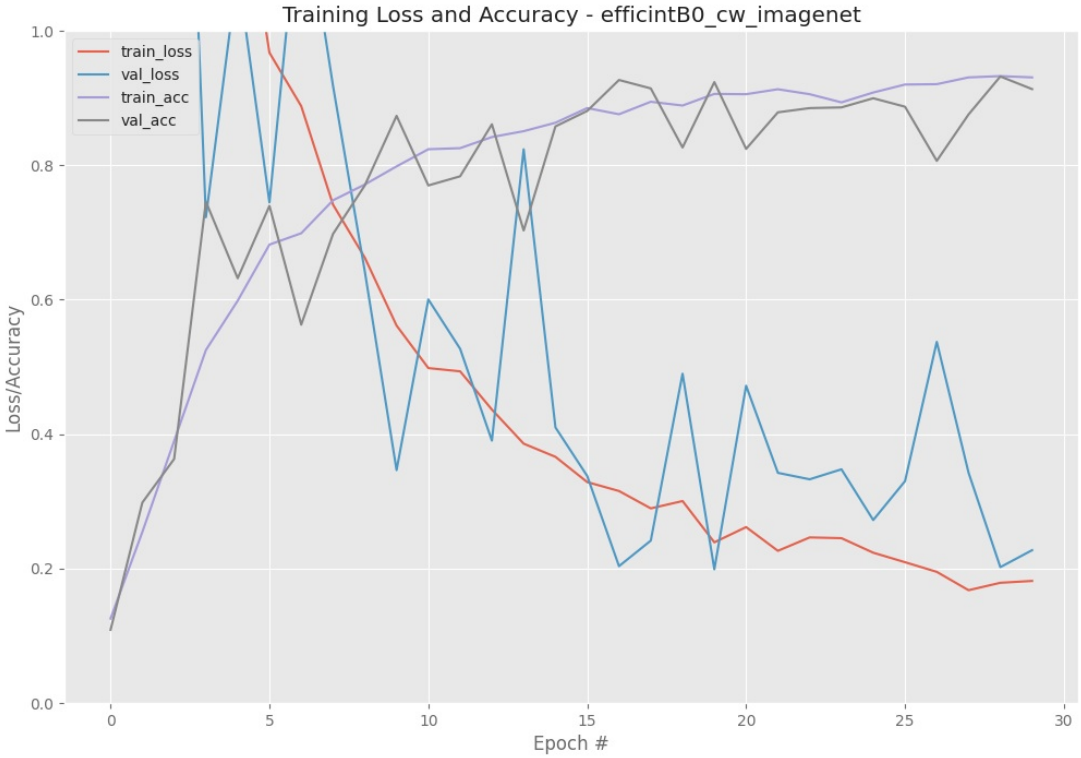
DenseNet121:



VGG16:



EfficientNetV2 B0:



La razón por la cual EfficientNetV2 ha dado los mejores resultados puede estar relacionada con varias razones:

- Mayor capacidad representativa: EfficientNetV2 puede capturar patrones más complejos y representaciones semánticas más profundas en comparación con arquitecturas más simples como VGG16. La arquitectura presenta capas de skip-connections mientras que la VGG16 no. Esto es especialmente beneficioso para tareas de clasificación en conjuntos de datos complejos.
- Arquitectura eficiente: EfficientNetV2 se diseñó específicamente para ser eficiente en términos de recursos computacionales y parámetros, manteniendo un buen rendimiento. Puede lograr una mayor eficiencia con respecto al uso de recursos como memoria y potencia de cálculo en comparación con arquitecturas más antiguas o menos eficientes. El resto de arquitecturas están sobredimensionadas para el problema propuesto

A pesar de que la EfficientNet ha dado los mejores resultados para resolver este problema, cabe destacar que los entrenamientos son muy erráticos y las curvas de entrenamiento son muy oscilatorias. No es el enfoque óptimo para resolver el problema, pero pensamos que una buena optimización de las redes pre-entrenadas podría darnos mejores resultados.