Proyecto 2 CNN - GRU

```
import pandas as pd
import numpy as np
import pydicom
from pydicom.pixel_data_handlers.util import apply_voi_lut
import os
import matplotlib.pyplot as plt
import matplotlib.animation as animation
from scipy import ndimage
import torch
import torch.nn as nn
import torchvision.transforms as transforms
import torchvision.models as models
from torch.utils.data import DataLoader, TensorDataset
import torch.optim as optim
import cv2
from PIL import Image
from zipfile import ZipFile
from torchvision import transforms
import torch.optim as optim
from torch.utils.tensorboard import SummaryWriter
import torch
import torch.nn as nn
from efficientnet_pytorch import EfficientNet
from tqdm import tqdm
import torch.nn.functional as F
from sklearn.decomposition import PCA
from sklearn.model_selection import train_test_split
from sklearn.metrics import precision_score, f1_score
```

```
sample = 600
```

```
data_VGG = pd.read_csv('train_filtrado_images.csv')
data_VGG = data_VGG.sample(n=sample, random_state=42)
```

```
data_vertebrae = pd.read_csv('meta_train_with_vertebrae.csv')
```

```
train_data, test_data = train_test_split(data_VGG, test_size=0.2, random_state=42)
```

```
# Parámetros del modelo
vgg_output_size = 1280  # Tamaño de la salida de la VGG16
gru_hidden_size = 128  # Tamaño del estado oculto de la GRU
```

```
gru_num_layers = 2  # Número de capas en la GRU
num_classes = 7  # Reemplaza con el número de clases en tu problema
```

```
class WeightedMultiLabelLogLoss(nn.Module):
    def __init__(self, weight=None):
        super(WeightedMultiLabelLogLoss, self).__init__()
        self.weight = weight

    def forward(self, input, target):
        """
        Computes the weighted multi-label logarithmic loss.

        Args:
            input (torch.Tensor): Predicted probabilities (output of the model).
                                  Shape: (batch_size, num_classes)
            target (torch.Tensor): Target labels (ground truth).
                                  Shape: (batch_size, num_classes)

        Returns:
            loss (torch.Tensor): Weighted multi-label logarithmic loss.
        """
        epsilon = 1e-15  # Small constant to avoid log(0)
        # Log loss
        log_loss = -target * torch.log(input + epsilon) - (1 - target) * torch.log(1 - input + ep

        # Apply weights if provided
        if self.weight is not None:
            log_loss = log_loss * self.weight

        # Compute mean loss over samples and classes
        loss = log_loss.mean()
        return loss
```

```
import torch.nn.functional as F

class CombinedModel(nn.Module):
    def __init__(self, efficientnet_output_size, gru_hidden_size, gru_num_layers, num_classes):
        super(CombinedModel, self).__init__()

        # Cargar EfficientNet preentrenado
        self.efficientnet = models.efficientnet_b0(pretrained=True)
        # Eliminar la capa Fully Connected
        self.features = nn.Sequential(*list(self.efficientnet.children())[:-1])

        # Pooling Global Promedio
        self.global_avg_pool = nn.AdaptiveAvgPool2d(1)

        # GRU Layer
```

```
        self.gru = nn.GRU(input_size=efficientnet_output_size, hidden_size=gru_hidden_size, batch_

        # Fully Connected Layer
        self.fc = nn.Linear(gru_hidden_size, 1)
        self.dropout = nn.Dropout(0.5)

        # Softmax
        # self.softmax = nn.Softmax(dim=1)
        self.sigmoid = nn.Sigmoid()

    def forward(self, x):
        batch_size, timesteps, C, H, W = x.size()
        x = x.view(batch_size * timesteps, C, H, W)

        # Pasar imágenes por EfficientNet
        x = self.features(x)

        # Pooling Global Promedio
        x = self.global_avg_pool(x).squeeze(-1).squeeze(-1)

        x = x.view(batch_size, timesteps, -1)
        # print(x.shape)
        # Pasar la secuencia de feature maps por la GRU
        out, _ = self.gru(x)
        # Usar solo la última salida de la secuencia
        out = out[:, -1, :]
        # Pasar por la capa Fully Connected
        out = self.dropout(self.fc(out))
        # Softmax
        out = self.sigmoid(out)

        return out
```

```
if torch.cuda.is_available():
    print('GPU está disponible')
else:
    print('No se encontró GPU, usando CPU')
```

```
GPU está disponible
```

```
# Crea una instancia del modelo combinado
combined_model = CombinedModel(vgg_output_size, gru_hidden_size, gru_num_layers, num_classes)
```

```
c:\Users\Daniel\Main\UVG\Semestre_VIII\Data_science\Proyecto2\envi\lib\site-
packages\torchvision\models\_utils.py:208: UserWarning: The parameter 'pretrained' is deprecated
since 0.13 and may be removed in the future, please use 'weights' instead.
  warnings.warn(
c:\Users\Daniel\Main\UVG\Semestre_VIII\Data_science\Proyecto2\envi\lib\site-
```

```
packages\torchvision\models\_utils.py:223: UserWarning: Arguments other than a weight enum or
`None` for 'weights' are deprecated since 0.13 and may be removed in the future. The current
behavior is equivalent to passing `weights=EfficientNet_B0_Weights.IMAGENET1K_V1`. You can also
use `weights=EfficientNet_B0_Weights.DEFAULT` to get the most up-to-date weights.
  warnings.warn(msg)
```

```python
combined_model.to('cuda')
```

```
CombinedModel(
  (efficientnet): EfficientNet(
    (features): Sequential(
      (0): Conv2dNormActivation(
        (0): Conv2d(3, 32, kernel_size=(3, 3), stride=(2, 2), padding=(1, 1), bias=False)
        (1): BatchNorm2d(32, eps=1e-05, momentum=0.1, affine=True, track_running_stats=True)
        (2): SiLU(inplace=True)
      )
      (1): Sequential(
        (0): MBConv(
          (block): Sequential(
            (0): Conv2dNormActivation(
              (0): Conv2d(32, 32, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1), groups=32,
bias=False)
              (1): BatchNorm2d(32, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
              (2): SiLU(inplace=True)
            )
            (1): SqueezeExcitation(
              (avgpool): AdaptiveAvgPool2d(output_size=1)
              (fc1): Conv2d(32, 8, kernel_size=(1, 1), stride=(1, 1))
              (fc2): Conv2d(8, 32, kernel_size=(1, 1), stride=(1, 1))
              (activation): SiLU(inplace=True)
              (scale_activation): Sigmoid()
            )
            (2): Conv2dNormActivation(
              (0): Conv2d(32, 16, kernel_size=(1, 1), stride=(1, 1), bias=False)
              (1): BatchNorm2d(16, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
            )
          )
          (stochastic_depth): StochasticDepth(p=0.0, mode=row)
        )
      )
      (2): Sequential(
        (0): MBConv(
          (block): Sequential(
            (0): Conv2dNormActivation(
              (0): Conv2d(16, 96, kernel_size=(1, 1), stride=(1, 1), bias=False)
              (1): BatchNorm2d(96, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
              (2): SiLU(inplace=True)
```

```
            )
            (1): Conv2dNormActivation(
              (0): Conv2d(96, 96, kernel_size=(3, 3), stride=(2, 2), padding=(1, 1), groups=96,
bias=False)
              (1): BatchNorm2d(96, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
              (2): SiLU(inplace=True)
            )
            (2): SqueezeExcitation(
              (avgpool): AdaptiveAvgPool2d(output_size=1)
              (fc1): Conv2d(96, 4, kernel_size=(1, 1), stride=(1, 1))
              (fc2): Conv2d(4, 96, kernel_size=(1, 1), stride=(1, 1))
              (activation): SiLU(inplace=True)
              (scale_activation): Sigmoid()
            )
            (3): Conv2dNormActivation(
              (0): Conv2d(96, 24, kernel_size=(1, 1), stride=(1, 1), bias=False)
              (1): BatchNorm2d(24, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
            )
          )
          (stochastic_depth): StochasticDepth(p=0.0125, mode=row)
        )
        (1): MBConv(
          (block): Sequential(
            (0): Conv2dNormActivation(
              (0): Conv2d(24, 144, kernel_size=(1, 1), stride=(1, 1), bias=False)
              (1): BatchNorm2d(144, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
              (2): SiLU(inplace=True)
            )
            (1): Conv2dNormActivation(
              (0): Conv2d(144, 144, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1),
groups=144, bias=False)
              (1): BatchNorm2d(144, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
              (2): SiLU(inplace=True)
            )
            (2): SqueezeExcitation(
              (avgpool): AdaptiveAvgPool2d(output_size=1)
              (fc1): Conv2d(144, 6, kernel_size=(1, 1), stride=(1, 1))
              (fc2): Conv2d(6, 144, kernel_size=(1, 1), stride=(1, 1))
              (activation): SiLU(inplace=True)
              (scale_activation): Sigmoid()
            )
            (3): Conv2dNormActivation(
              (0): Conv2d(144, 24, kernel_size=(1, 1), stride=(1, 1), bias=False)
              (1): BatchNorm2d(24, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
            )
          )
```

```
          (stochastic_depth): StochasticDepth(p=0.025, mode=row)
        )
      )
      (3): Sequential(
        (0): MBConv(
          (block): Sequential(
            (0): Conv2dNormActivation(
              (0): Conv2d(24, 144, kernel_size=(1, 1), stride=(1, 1), bias=False)
              (1): BatchNorm2d(144, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
              (2): SiLU(inplace=True)
            )
            (1): Conv2dNormActivation(
              (0): Conv2d(144, 144, kernel_size=(5, 5), stride=(2, 2), padding=(2, 2),
groups=144, bias=False)
              (1): BatchNorm2d(144, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
              (2): SiLU(inplace=True)
            )
            (2): SqueezeExcitation(
              (avgpool): AdaptiveAvgPool2d(output_size=1)
              (fc1): Conv2d(144, 6, kernel_size=(1, 1), stride=(1, 1))
              (fc2): Conv2d(6, 144, kernel_size=(1, 1), stride=(1, 1))
              (activation): SiLU(inplace=True)
              (scale_activation): Sigmoid()
            )
            (3): Conv2dNormActivation(
              (0): Conv2d(144, 40, kernel_size=(1, 1), stride=(1, 1), bias=False)
              (1): BatchNorm2d(40, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
            )
          )
          (stochastic_depth): StochasticDepth(p=0.037500000000000006, mode=row)
        )
        (1): MBConv(
          (block): Sequential(
            (0): Conv2dNormActivation(
              (0): Conv2d(40, 240, kernel_size=(1, 1), stride=(1, 1), bias=False)
              (1): BatchNorm2d(240, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
              (2): SiLU(inplace=True)
            )
            (1): Conv2dNormActivation(
              (0): Conv2d(240, 240, kernel_size=(5, 5), stride=(1, 1), padding=(2, 2),
groups=240, bias=False)
              (1): BatchNorm2d(240, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
              (2): SiLU(inplace=True)
            )
            (2): SqueezeExcitation(
              (avgpool): AdaptiveAvgPool2d(output_size=1)
```

```
              (fc1): Conv2d(240, 10, kernel_size=(1, 1), stride=(1, 1))
              (fc2): Conv2d(10, 240, kernel_size=(1, 1), stride=(1, 1))
              (activation): SiLU(inplace=True)
              (scale_activation): Sigmoid()
            )
            (3): Conv2dNormActivation(
              (0): Conv2d(240, 40, kernel_size=(1, 1), stride=(1, 1), bias=False)
              (1): BatchNorm2d(40, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
            )
          )
          (stochastic_depth): StochasticDepth(p=0.05, mode=row)
        )
      )
      (4): Sequential(
        (0): MBConv(
          (block): Sequential(
            (0): Conv2dNormActivation(
              (0): Conv2d(40, 240, kernel_size=(1, 1), stride=(1, 1), bias=False)
              (1): BatchNorm2d(240, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
              (2): SiLU(inplace=True)
            )
            (1): Conv2dNormActivation(
              (0): Conv2d(240, 240, kernel_size=(3, 3), stride=(2, 2), padding=(1, 1),
groups=240, bias=False)
              (1): BatchNorm2d(240, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
              (2): SiLU(inplace=True)
            )
            (2): SqueezeExcitation(
              (avgpool): AdaptiveAvgPool2d(output_size=1)
              (fc1): Conv2d(240, 10, kernel_size=(1, 1), stride=(1, 1))
              (fc2): Conv2d(10, 240, kernel_size=(1, 1), stride=(1, 1))
              (activation): SiLU(inplace=True)
              (scale_activation): Sigmoid()
            )
            (3): Conv2dNormActivation(
              (0): Conv2d(240, 80, kernel_size=(1, 1), stride=(1, 1), bias=False)
              (1): BatchNorm2d(80, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
            )
          )
          (stochastic_depth): StochasticDepth(p=0.0625, mode=row)
        )
        (1): MBConv(
          (block): Sequential(
            (0): Conv2dNormActivation(
              (0): Conv2d(80, 480, kernel_size=(1, 1), stride=(1, 1), bias=False)
              (1): BatchNorm2d(480, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
```

```
              (2): SiLU(inplace=True)
            )
            (1): Conv2dNormActivation(
              (0): Conv2d(480, 480, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1),
groups=480, bias=False)
              (1): BatchNorm2d(480, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
              (2): SiLU(inplace=True)
            )
            (2): SqueezeExcitation(
              (avgpool): AdaptiveAvgPool2d(output_size=1)
              (fc1): Conv2d(480, 20, kernel_size=(1, 1), stride=(1, 1))
              (fc2): Conv2d(20, 480, kernel_size=(1, 1), stride=(1, 1))
              (activation): SiLU(inplace=True)
              (scale_activation): Sigmoid()
            )
            (3): Conv2dNormActivation(
              (0): Conv2d(480, 80, kernel_size=(1, 1), stride=(1, 1), bias=False)
              (1): BatchNorm2d(80, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
            )
          )
          (stochastic_depth): StochasticDepth(p=0.07500000000000001, mode=row)
        )
        (2): MBConv(
          (block): Sequential(
            (0): Conv2dNormActivation(
              (0): Conv2d(80, 480, kernel_size=(1, 1), stride=(1, 1), bias=False)
              (1): BatchNorm2d(480, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
              (2): SiLU(inplace=True)
            )
            (1): Conv2dNormActivation(
              (0): Conv2d(480, 480, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1),
groups=480, bias=False)
              (1): BatchNorm2d(480, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
              (2): SiLU(inplace=True)
            )
            (2): SqueezeExcitation(
              (avgpool): AdaptiveAvgPool2d(output_size=1)
              (fc1): Conv2d(480, 20, kernel_size=(1, 1), stride=(1, 1))
              (fc2): Conv2d(20, 480, kernel_size=(1, 1), stride=(1, 1))
              (activation): SiLU(inplace=True)
              (scale_activation): Sigmoid()
            )
            (3): Conv2dNormActivation(
              (0): Conv2d(480, 80, kernel_size=(1, 1), stride=(1, 1), bias=False)
              (1): BatchNorm2d(80, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
            )
```

```
          )
          (stochastic_depth): StochasticDepth(p=0.08750000000000001, mode=row)
        )
      )
      (5): Sequential(
        (0): MBConv(
          (block): Sequential(
            (0): Conv2dNormActivation(
              (0): Conv2d(80, 480, kernel_size=(1, 1), stride=(1, 1), bias=False)
              (1): BatchNorm2d(480, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
              (2): SiLU(inplace=True)
            )
            (1): Conv2dNormActivation(
              (0): Conv2d(480, 480, kernel_size=(5, 5), stride=(1, 1), padding=(2, 2),
groups=480, bias=False)
              (1): BatchNorm2d(480, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
              (2): SiLU(inplace=True)
            )
            (2): SqueezeExcitation(
              (avgpool): AdaptiveAvgPool2d(output_size=1)
              (fc1): Conv2d(480, 20, kernel_size=(1, 1), stride=(1, 1))
              (fc2): Conv2d(20, 480, kernel_size=(1, 1), stride=(1, 1))
              (activation): SiLU(inplace=True)
              (scale_activation): Sigmoid()
            )
            (3): Conv2dNormActivation(
              (0): Conv2d(480, 112, kernel_size=(1, 1), stride=(1, 1), bias=False)
              (1): BatchNorm2d(112, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
            )
          )
          (stochastic_depth): StochasticDepth(p=0.1, mode=row)
        )
        (1): MBConv(
          (block): Sequential(
            (0): Conv2dNormActivation(
              (0): Conv2d(112, 672, kernel_size=(1, 1), stride=(1, 1), bias=False)
              (1): BatchNorm2d(672, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
              (2): SiLU(inplace=True)
            )
            (1): Conv2dNormActivation(
              (0): Conv2d(672, 672, kernel_size=(5, 5), stride=(1, 1), padding=(2, 2),
groups=672, bias=False)
              (1): BatchNorm2d(672, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
              (2): SiLU(inplace=True)
            )
            (2): SqueezeExcitation(
```

```
            (avgpool): AdaptiveAvgPool2d(output_size=1)
            (fc1): Conv2d(672, 28, kernel_size=(1, 1), stride=(1, 1))
            (fc2): Conv2d(28, 672, kernel_size=(1, 1), stride=(1, 1))
            (activation): SiLU(inplace=True)
            (scale_activation): Sigmoid()
          )
          (3): Conv2dNormActivation(
            (0): Conv2d(672, 112, kernel_size=(1, 1), stride=(1, 1), bias=False)
            (1): BatchNorm2d(112, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
          )
        )
        (stochastic_depth): StochasticDepth(p=0.1125, mode=row)
      )
      (2): MBConv(
        (block): Sequential(
          (0): Conv2dNormActivation(
            (0): Conv2d(112, 672, kernel_size=(1, 1), stride=(1, 1), bias=False)
            (1): BatchNorm2d(672, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
            (2): SiLU(inplace=True)
          )
          (1): Conv2dNormActivation(
            (0): Conv2d(672, 672, kernel_size=(5, 5), stride=(1, 1), padding=(2, 2),
groups=672, bias=False)
            (1): BatchNorm2d(672, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
            (2): SiLU(inplace=True)
          )
          (2): SqueezeExcitation(
            (avgpool): AdaptiveAvgPool2d(output_size=1)
            (fc1): Conv2d(672, 28, kernel_size=(1, 1), stride=(1, 1))
            (fc2): Conv2d(28, 672, kernel_size=(1, 1), stride=(1, 1))
            (activation): SiLU(inplace=True)
            (scale_activation): Sigmoid()
          )
          (3): Conv2dNormActivation(
            (0): Conv2d(672, 112, kernel_size=(1, 1), stride=(1, 1), bias=False)
            (1): BatchNorm2d(112, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
          )
        )
        (stochastic_depth): StochasticDepth(p=0.125, mode=row)
      )
    )
    (6): Sequential(
      (0): MBConv(
        (block): Sequential(
          (0): Conv2dNormActivation(
            (0): Conv2d(112, 672, kernel_size=(1, 1), stride=(1, 1), bias=False)
            (1): BatchNorm2d(672, eps=1e-05, momentum=0.1, affine=True,
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```
track_running_stats=True)
              (2): SiLU(inplace=True)
            )
            (1): Conv2dNormActivation(
              (0): Conv2d(672, 672, kernel_size=(5, 5), stride=(2, 2), padding=(2, 2),
groups=672, bias=False)
              (1): BatchNorm2d(672, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
              (2): SiLU(inplace=True)
            )
            (2): SqueezeExcitation(
              (avgpool): AdaptiveAvgPool2d(output_size=1)
              (fc1): Conv2d(672, 28, kernel_size=(1, 1), stride=(1, 1))
              (fc2): Conv2d(28, 672, kernel_size=(1, 1), stride=(1, 1))
              (activation): SiLU(inplace=True)
              (scale_activation): Sigmoid()
            )
            (3): Conv2dNormActivation(
              (0): Conv2d(672, 192, kernel_size=(1, 1), stride=(1, 1), bias=False)
              (1): BatchNorm2d(192, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
            )
          )
          (stochastic_depth): StochasticDepth(p=0.1375, mode=row)
        )
        (1): MBConv(
          (block): Sequential(
            (0): Conv2dNormActivation(
              (0): Conv2d(192, 1152, kernel_size=(1, 1), stride=(1, 1), bias=False)
              (1): BatchNorm2d(1152, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
              (2): SiLU(inplace=True)
            )
            (1): Conv2dNormActivation(
              (0): Conv2d(1152, 1152, kernel_size=(5, 5), stride=(1, 1), padding=(2, 2),
groups=1152, bias=False)
              (1): BatchNorm2d(1152, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
              (2): SiLU(inplace=True)
            )
            (2): SqueezeExcitation(
              (avgpool): AdaptiveAvgPool2d(output_size=1)
              (fc1): Conv2d(1152, 48, kernel_size=(1, 1), stride=(1, 1))
              (fc2): Conv2d(48, 1152, kernel_size=(1, 1), stride=(1, 1))
              (activation): SiLU(inplace=True)
              (scale_activation): Sigmoid()
            )
            (3): Conv2dNormActivation(
              (0): Conv2d(1152, 192, kernel_size=(1, 1), stride=(1, 1), bias=False)
              (1): BatchNorm2d(192, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
```

```
            )
          )
          (stochastic_depth): StochasticDepth(p=0.15000000000000002, mode=row)
        )
        (2): MBConv(
          (block): Sequential(
            (0): Conv2dNormActivation(
              (0): Conv2d(192, 1152, kernel_size=(1, 1), stride=(1, 1), bias=False)
              (1): BatchNorm2d(1152, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
              (2): SiLU(inplace=True)
            )
            (1): Conv2dNormActivation(
              (0): Conv2d(1152, 1152, kernel_size=(5, 5), stride=(1, 1), padding=(2, 2),
groups=1152, bias=False)
              (1): BatchNorm2d(1152, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
              (2): SiLU(inplace=True)
            )
            (2): SqueezeExcitation(
              (avgpool): AdaptiveAvgPool2d(output_size=1)
              (fc1): Conv2d(1152, 48, kernel_size=(1, 1), stride=(1, 1))
              (fc2): Conv2d(48, 1152, kernel_size=(1, 1), stride=(1, 1))
              (activation): SiLU(inplace=True)
              (scale_activation): Sigmoid()
            )
            (3): Conv2dNormActivation(
              (0): Conv2d(1152, 192, kernel_size=(1, 1), stride=(1, 1), bias=False)
              (1): BatchNorm2d(192, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
            )
          )
          (stochastic_depth): StochasticDepth(p=0.1625, mode=row)
        )
        (3): MBConv(
          (block): Sequential(
            (0): Conv2dNormActivation(
              (0): Conv2d(192, 1152, kernel_size=(1, 1), stride=(1, 1), bias=False)
              (1): BatchNorm2d(1152, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
              (2): SiLU(inplace=True)
            )
            (1): Conv2dNormActivation(
              (0): Conv2d(1152, 1152, kernel_size=(5, 5), stride=(1, 1), padding=(2, 2),
groups=1152, bias=False)
              (1): BatchNorm2d(1152, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
              (2): SiLU(inplace=True)
            )
            (2): SqueezeExcitation(
              (avgpool): AdaptiveAvgPool2d(output_size=1)
```

```
              (fc1): Conv2d(1152, 48, kernel_size=(1, 1), stride=(1, 1))
              (fc2): Conv2d(48, 1152, kernel_size=(1, 1), stride=(1, 1))
              (activation): SiLU(inplace=True)
              (scale_activation): Sigmoid()
            )
            (3): Conv2dNormActivation(
              (0): Conv2d(1152, 192, kernel_size=(1, 1), stride=(1, 1), bias=False)
              (1): BatchNorm2d(192, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
            )
          )
          (stochastic_depth): StochasticDepth(p=0.17500000000000002, mode=row)
        )
      )
      (7): Sequential(
        (0): MBConv(
          (block): Sequential(
            (0): Conv2dNormActivation(
              (0): Conv2d(192, 1152, kernel_size=(1, 1), stride=(1, 1), bias=False)
              (1): BatchNorm2d(1152, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
              (2): SiLU(inplace=True)
            )
            (1): Conv2dNormActivation(
              (0): Conv2d(1152, 1152, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1),
groups=1152, bias=False)
              (1): BatchNorm2d(1152, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
              (2): SiLU(inplace=True)
            )
            (2): SqueezeExcitation(
              (avgpool): AdaptiveAvgPool2d(output_size=1)
              (fc1): Conv2d(1152, 48, kernel_size=(1, 1), stride=(1, 1))
              (fc2): Conv2d(48, 1152, kernel_size=(1, 1), stride=(1, 1))
              (activation): SiLU(inplace=True)
              (scale_activation): Sigmoid()
            )
            (3): Conv2dNormActivation(
              (0): Conv2d(1152, 320, kernel_size=(1, 1), stride=(1, 1), bias=False)
              (1): BatchNorm2d(320, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
            )
          )
          (stochastic_depth): StochasticDepth(p=0.1875, mode=row)
        )
      )
      (8): Conv2dNormActivation(
        (0): Conv2d(320, 1280, kernel_size=(1, 1), stride=(1, 1), bias=False)
        (1): BatchNorm2d(1280, eps=1e-05, momentum=0.1, affine=True, track_running_stats=True)
        (2): SiLU(inplace=True)
      )
```

```
    )
    (avgpool): AdaptiveAvgPool2d(output_size=1)
    (classifier): Sequential(
      (0): Dropout(p=0.2, inplace=True)
      (1): Linear(in_features=1280, out_features=1000, bias=True)
    )
  )
  (features): Sequential(
    (0): Sequential(
      (0): Conv2dNormActivation(
        (0): Conv2d(3, 32, kernel_size=(3, 3), stride=(2, 2), padding=(1, 1), bias=False)
        (1): BatchNorm2d(32, eps=1e-05, momentum=0.1, affine=True, track_running_stats=True)
        (2): SiLU(inplace=True)
      )
      (1): Sequential(
        (0): MBConv(
          (block): Sequential(
            (0): Conv2dNormActivation(
              (0): Conv2d(32, 32, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1), groups=32,
bias=False)
              (1): BatchNorm2d(32, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
              (2): SiLU(inplace=True)
            )
            (1): SqueezeExcitation(
              (avgpool): AdaptiveAvgPool2d(output_size=1)
              (fc1): Conv2d(32, 8, kernel_size=(1, 1), stride=(1, 1))
              (fc2): Conv2d(8, 32, kernel_size=(1, 1), stride=(1, 1))
              (activation): SiLU(inplace=True)
              (scale_activation): Sigmoid()
            )
            (2): Conv2dNormActivation(
              (0): Conv2d(32, 16, kernel_size=(1, 1), stride=(1, 1), bias=False)
              (1): BatchNorm2d(16, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
            )
          )
          (stochastic_depth): StochasticDepth(p=0.0, mode=row)
        )
      )
      (2): Sequential(
        (0): MBConv(
          (block): Sequential(
            (0): Conv2dNormActivation(
              (0): Conv2d(16, 96, kernel_size=(1, 1), stride=(1, 1), bias=False)
              (1): BatchNorm2d(96, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
              (2): SiLU(inplace=True)
            )
            (1): Conv2dNormActivation(
              (0): Conv2d(96, 96, kernel_size=(3, 3), stride=(2, 2), padding=(1, 1), groups=96,
```

```
bias=False)
              (1): BatchNorm2d(96, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
              (2): SiLU(inplace=True)
            )
            (2): SqueezeExcitation(
              (avgpool): AdaptiveAvgPool2d(output_size=1)
              (fc1): Conv2d(96, 4, kernel_size=(1, 1), stride=(1, 1))
              (fc2): Conv2d(4, 96, kernel_size=(1, 1), stride=(1, 1))
              (activation): SiLU(inplace=True)
              (scale_activation): Sigmoid()
            )
            (3): Conv2dNormActivation(
              (0): Conv2d(96, 24, kernel_size=(1, 1), stride=(1, 1), bias=False)
              (1): BatchNorm2d(24, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
            )
          )
          (stochastic_depth): StochasticDepth(p=0.0125, mode=row)
        )
        (1): MBConv(
          (block): Sequential(
            (0): Conv2dNormActivation(
              (0): Conv2d(24, 144, kernel_size=(1, 1), stride=(1, 1), bias=False)
              (1): BatchNorm2d(144, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
              (2): SiLU(inplace=True)
            )
            (1): Conv2dNormActivation(
              (0): Conv2d(144, 144, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1),
groups=144, bias=False)
              (1): BatchNorm2d(144, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
              (2): SiLU(inplace=True)
            )
            (2): SqueezeExcitation(
              (avgpool): AdaptiveAvgPool2d(output_size=1)
              (fc1): Conv2d(144, 6, kernel_size=(1, 1), stride=(1, 1))
              (fc2): Conv2d(6, 144, kernel_size=(1, 1), stride=(1, 1))
              (activation): SiLU(inplace=True)
              (scale_activation): Sigmoid()
            )
            (3): Conv2dNormActivation(
              (0): Conv2d(144, 24, kernel_size=(1, 1), stride=(1, 1), bias=False)
              (1): BatchNorm2d(24, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
            )
          )
          (stochastic_depth): StochasticDepth(p=0.025, mode=row)
        )
      )
```

```
      (3): Sequential(
        (0): MBConv(
          (block): Sequential(
            (0): Conv2dNormActivation(
              (0): Conv2d(24, 144, kernel_size=(1, 1), stride=(1, 1), bias=False)
              (1): BatchNorm2d(144, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
              (2): SiLU(inplace=True)
            )
            (1): Conv2dNormActivation(
              (0): Conv2d(144, 144, kernel_size=(5, 5), stride=(2, 2), padding=(2, 2),
groups=144, bias=False)
              (1): BatchNorm2d(144, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
              (2): SiLU(inplace=True)
            )
            (2): SqueezeExcitation(
              (avgpool): AdaptiveAvgPool2d(output_size=1)
              (fc1): Conv2d(144, 6, kernel_size=(1, 1), stride=(1, 1))
              (fc2): Conv2d(6, 144, kernel_size=(1, 1), stride=(1, 1))
              (activation): SiLU(inplace=True)
              (scale_activation): Sigmoid()
            )
            (3): Conv2dNormActivation(
              (0): Conv2d(144, 40, kernel_size=(1, 1), stride=(1, 1), bias=False)
              (1): BatchNorm2d(40, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
            )
          )
          (stochastic_depth): StochasticDepth(p=0.037500000000000006, mode=row)
        )
        (1): MBConv(
          (block): Sequential(
            (0): Conv2dNormActivation(
              (0): Conv2d(40, 240, kernel_size=(1, 1), stride=(1, 1), bias=False)
              (1): BatchNorm2d(240, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
              (2): SiLU(inplace=True)
            )
            (1): Conv2dNormActivation(
              (0): Conv2d(240, 240, kernel_size=(5, 5), stride=(1, 1), padding=(2, 2),
groups=240, bias=False)
              (1): BatchNorm2d(240, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
              (2): SiLU(inplace=True)
            )
            (2): SqueezeExcitation(
              (avgpool): AdaptiveAvgPool2d(output_size=1)
              (fc1): Conv2d(240, 10, kernel_size=(1, 1), stride=(1, 1))
              (fc2): Conv2d(10, 240, kernel_size=(1, 1), stride=(1, 1))
              (activation): SiLU(inplace=True)
```

```
            (scale_activation): Sigmoid()
          )
          (3): Conv2dNormActivation(
            (0): Conv2d(240, 40, kernel_size=(1, 1), stride=(1, 1), bias=False)
            (1): BatchNorm2d(40, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
          )
        )
        (stochastic_depth): StochasticDepth(p=0.05, mode=row)
      )
    )
    (4): Sequential(
      (0): MBConv(
        (block): Sequential(
          (0): Conv2dNormActivation(
            (0): Conv2d(40, 240, kernel_size=(1, 1), stride=(1, 1), bias=False)
            (1): BatchNorm2d(240, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
            (2): SiLU(inplace=True)
          )
          (1): Conv2dNormActivation(
            (0): Conv2d(240, 240, kernel_size=(3, 3), stride=(2, 2), padding=(1, 1),
groups=240, bias=False)
            (1): BatchNorm2d(240, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
            (2): SiLU(inplace=True)
          )
          (2): SqueezeExcitation(
            (avgpool): AdaptiveAvgPool2d(output_size=1)
            (fc1): Conv2d(240, 10, kernel_size=(1, 1), stride=(1, 1))
            (fc2): Conv2d(10, 240, kernel_size=(1, 1), stride=(1, 1))
            (activation): SiLU(inplace=True)
            (scale_activation): Sigmoid()
          )
          (3): Conv2dNormActivation(
            (0): Conv2d(240, 80, kernel_size=(1, 1), stride=(1, 1), bias=False)
            (1): BatchNorm2d(80, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
          )
        )
        (stochastic_depth): StochasticDepth(p=0.0625, mode=row)
      )
      (1): MBConv(
        (block): Sequential(
          (0): Conv2dNormActivation(
            (0): Conv2d(80, 480, kernel_size=(1, 1), stride=(1, 1), bias=False)
            (1): BatchNorm2d(480, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
            (2): SiLU(inplace=True)
          )
          (1): Conv2dNormActivation(
```

```
              (0): Conv2d(480, 480, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1),
groups=480, bias=False)
              (1): BatchNorm2d(480, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
              (2): SiLU(inplace=True)
            )
            (2): SqueezeExcitation(
              (avgpool): AdaptiveAvgPool2d(output_size=1)
              (fc1): Conv2d(480, 20, kernel_size=(1, 1), stride=(1, 1))
              (fc2): Conv2d(20, 480, kernel_size=(1, 1), stride=(1, 1))
              (activation): SiLU(inplace=True)
              (scale_activation): Sigmoid()
            )
            (3): Conv2dNormActivation(
              (0): Conv2d(480, 80, kernel_size=(1, 1), stride=(1, 1), bias=False)
              (1): BatchNorm2d(80, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
            )
          )
          (stochastic_depth): StochasticDepth(p=0.07500000000000001, mode=row)
        )
        (2): MBConv(
          (block): Sequential(
            (0): Conv2dNormActivation(
              (0): Conv2d(80, 480, kernel_size=(1, 1), stride=(1, 1), bias=False)
              (1): BatchNorm2d(480, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
              (2): SiLU(inplace=True)
            )
            (1): Conv2dNormActivation(
              (0): Conv2d(480, 480, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1),
groups=480, bias=False)
              (1): BatchNorm2d(480, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
              (2): SiLU(inplace=True)
            )
            (2): SqueezeExcitation(
              (avgpool): AdaptiveAvgPool2d(output_size=1)
              (fc1): Conv2d(480, 20, kernel_size=(1, 1), stride=(1, 1))
              (fc2): Conv2d(20, 480, kernel_size=(1, 1), stride=(1, 1))
              (activation): SiLU(inplace=True)
              (scale_activation): Sigmoid()
            )
            (3): Conv2dNormActivation(
              (0): Conv2d(480, 80, kernel_size=(1, 1), stride=(1, 1), bias=False)
              (1): BatchNorm2d(80, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
            )
          )
          (stochastic_depth): StochasticDepth(p=0.08750000000000001, mode=row)
        )
```

```
        )
        (5): Sequential(
          (0): MBConv(
            (block): Sequential(
              (0): Conv2dNormActivation(
                (0): Conv2d(80, 480, kernel_size=(1, 1), stride=(1, 1), bias=False)
                (1): BatchNorm2d(480, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
                (2): SiLU(inplace=True)
              )
              (1): Conv2dNormActivation(
                (0): Conv2d(480, 480, kernel_size=(5, 5), stride=(1, 1), padding=(2, 2),
groups=480, bias=False)
                (1): BatchNorm2d(480, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
                (2): SiLU(inplace=True)
              )
              (2): SqueezeExcitation(
                (avgpool): AdaptiveAvgPool2d(output_size=1)
                (fc1): Conv2d(480, 20, kernel_size=(1, 1), stride=(1, 1))
                (fc2): Conv2d(20, 480, kernel_size=(1, 1), stride=(1, 1))
                (activation): SiLU(inplace=True)
                (scale_activation): Sigmoid()
              )
              (3): Conv2dNormActivation(
                (0): Conv2d(480, 112, kernel_size=(1, 1), stride=(1, 1), bias=False)
                (1): BatchNorm2d(112, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
              )
            )
            (stochastic_depth): StochasticDepth(p=0.1, mode=row)
          )
          (1): MBConv(
            (block): Sequential(
              (0): Conv2dNormActivation(
                (0): Conv2d(112, 672, kernel_size=(1, 1), stride=(1, 1), bias=False)
                (1): BatchNorm2d(672, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
                (2): SiLU(inplace=True)
              )
              (1): Conv2dNormActivation(
                (0): Conv2d(672, 672, kernel_size=(5, 5), stride=(1, 1), padding=(2, 2),
groups=672, bias=False)
                (1): BatchNorm2d(672, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
                (2): SiLU(inplace=True)
              )
              (2): SqueezeExcitation(
                (avgpool): AdaptiveAvgPool2d(output_size=1)
                (fc1): Conv2d(672, 28, kernel_size=(1, 1), stride=(1, 1))
                (fc2): Conv2d(28, 672, kernel_size=(1, 1), stride=(1, 1))
```

```
              (activation): SiLU(inplace=True)
              (scale_activation): Sigmoid()
            )
            (3): Conv2dNormActivation(
              (0): Conv2d(672, 112, kernel_size=(1, 1), stride=(1, 1), bias=False)
              (1): BatchNorm2d(112, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
            )
          )
          (stochastic_depth): StochasticDepth(p=0.1125, mode=row)
        )
        (2): MBConv(
          (block): Sequential(
            (0): Conv2dNormActivation(
              (0): Conv2d(112, 672, kernel_size=(1, 1), stride=(1, 1), bias=False)
              (1): BatchNorm2d(672, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
              (2): SiLU(inplace=True)
            )
            (1): Conv2dNormActivation(
              (0): Conv2d(672, 672, kernel_size=(5, 5), stride=(1, 1), padding=(2, 2),
groups=672, bias=False)
              (1): BatchNorm2d(672, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
              (2): SiLU(inplace=True)
            )
            (2): SqueezeExcitation(
              (avgpool): AdaptiveAvgPool2d(output_size=1)
              (fc1): Conv2d(672, 28, kernel_size=(1, 1), stride=(1, 1))
              (fc2): Conv2d(28, 672, kernel_size=(1, 1), stride=(1, 1))
              (activation): SiLU(inplace=True)
              (scale_activation): Sigmoid()
            )
            (3): Conv2dNormActivation(
              (0): Conv2d(672, 112, kernel_size=(1, 1), stride=(1, 1), bias=False)
              (1): BatchNorm2d(112, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
            )
          )
          (stochastic_depth): StochasticDepth(p=0.125, mode=row)
        )
      )
      (6): Sequential(
        (0): MBConv(
          (block): Sequential(
            (0): Conv2dNormActivation(
              (0): Conv2d(112, 672, kernel_size=(1, 1), stride=(1, 1), bias=False)
              (1): BatchNorm2d(672, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
              (2): SiLU(inplace=True)
            )
```

```
            (1): Conv2dNormActivation(
              (0): Conv2d(672, 672, kernel_size=(5, 5), stride=(2, 2), padding=(2, 2),
groups=672, bias=False)
              (1): BatchNorm2d(672, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
              (2): SiLU(inplace=True)
            )
            (2): SqueezeExcitation(
              (avgpool): AdaptiveAvgPool2d(output_size=1)
              (fc1): Conv2d(672, 28, kernel_size=(1, 1), stride=(1, 1))
              (fc2): Conv2d(28, 672, kernel_size=(1, 1), stride=(1, 1))
              (activation): SiLU(inplace=True)
              (scale_activation): Sigmoid()
            )
            (3): Conv2dNormActivation(
              (0): Conv2d(672, 192, kernel_size=(1, 1), stride=(1, 1), bias=False)
              (1): BatchNorm2d(192, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
            )
          )
          (stochastic_depth): StochasticDepth(p=0.1375, mode=row)
        )
        (1): MBConv(
          (block): Sequential(
            (0): Conv2dNormActivation(
              (0): Conv2d(192, 1152, kernel_size=(1, 1), stride=(1, 1), bias=False)
              (1): BatchNorm2d(1152, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
              (2): SiLU(inplace=True)
            )
            (1): Conv2dNormActivation(
              (0): Conv2d(1152, 1152, kernel_size=(5, 5), stride=(1, 1), padding=(2, 2),
groups=1152, bias=False)
              (1): BatchNorm2d(1152, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
              (2): SiLU(inplace=True)
            )
            (2): SqueezeExcitation(
              (avgpool): AdaptiveAvgPool2d(output_size=1)
              (fc1): Conv2d(1152, 48, kernel_size=(1, 1), stride=(1, 1))
              (fc2): Conv2d(48, 1152, kernel_size=(1, 1), stride=(1, 1))
              (activation): SiLU(inplace=True)
              (scale_activation): Sigmoid()
            )
            (3): Conv2dNormActivation(
              (0): Conv2d(1152, 192, kernel_size=(1, 1), stride=(1, 1), bias=False)
              (1): BatchNorm2d(192, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
            )
          )
          (stochastic_depth): StochasticDepth(p=0.15000000000000002, mode=row)
```

```
        )
        (2): MBConv(
          (block): Sequential(
            (0): Conv2dNormActivation(
              (0): Conv2d(192, 1152, kernel_size=(1, 1), stride=(1, 1), bias=False)
              (1): BatchNorm2d(1152, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
              (2): SiLU(inplace=True)
            )
            (1): Conv2dNormActivation(
              (0): Conv2d(1152, 1152, kernel_size=(5, 5), stride=(1, 1), padding=(2, 2),
groups=1152, bias=False)
              (1): BatchNorm2d(1152, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
              (2): SiLU(inplace=True)
            )
            (2): SqueezeExcitation(
              (avgpool): AdaptiveAvgPool2d(output_size=1)
              (fc1): Conv2d(1152, 48, kernel_size=(1, 1), stride=(1, 1))
              (fc2): Conv2d(48, 1152, kernel_size=(1, 1), stride=(1, 1))
              (activation): SiLU(inplace=True)
              (scale_activation): Sigmoid()
            )
            (3): Conv2dNormActivation(
              (0): Conv2d(1152, 192, kernel_size=(1, 1), stride=(1, 1), bias=False)
              (1): BatchNorm2d(192, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
            )
          )
          (stochastic_depth): StochasticDepth(p=0.1625, mode=row)
        )
        (3): MBConv(
          (block): Sequential(
            (0): Conv2dNormActivation(
              (0): Conv2d(192, 1152, kernel_size=(1, 1), stride=(1, 1), bias=False)
              (1): BatchNorm2d(1152, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
              (2): SiLU(inplace=True)
            )
            (1): Conv2dNormActivation(
              (0): Conv2d(1152, 1152, kernel_size=(5, 5), stride=(1, 1), padding=(2, 2),
groups=1152, bias=False)
              (1): BatchNorm2d(1152, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
              (2): SiLU(inplace=True)
            )
            (2): SqueezeExcitation(
              (avgpool): AdaptiveAvgPool2d(output_size=1)
              (fc1): Conv2d(1152, 48, kernel_size=(1, 1), stride=(1, 1))
              (fc2): Conv2d(48, 1152, kernel_size=(1, 1), stride=(1, 1))
              (activation): SiLU(inplace=True)
```

```
            (scale_activation): Sigmoid()
          )
          (3): Conv2dNormActivation(
            (0): Conv2d(1152, 192, kernel_size=(1, 1), stride=(1, 1), bias=False)
            (1): BatchNorm2d(192, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
          )
        )
        (stochastic_depth): StochasticDepth(p=0.17500000000000002, mode=row)
      )
    )
    (7): Sequential(
      (0): MBConv(
        (block): Sequential(
          (0): Conv2dNormActivation(
            (0): Conv2d(192, 1152, kernel_size=(1, 1), stride=(1, 1), bias=False)
            (1): BatchNorm2d(1152, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
            (2): SiLU(inplace=True)
          )
          (1): Conv2dNormActivation(
            (0): Conv2d(1152, 1152, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1),
groups=1152, bias=False)
            (1): BatchNorm2d(1152, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
            (2): SiLU(inplace=True)
          )
          (2): SqueezeExcitation(
            (avgpool): AdaptiveAvgPool2d(output_size=1)
            (fc1): Conv2d(1152, 48, kernel_size=(1, 1), stride=(1, 1))
            (fc2): Conv2d(48, 1152, kernel_size=(1, 1), stride=(1, 1))
            (activation): SiLU(inplace=True)
            (scale_activation): Sigmoid()
          )
          (3): Conv2dNormActivation(
            (0): Conv2d(1152, 320, kernel_size=(1, 1), stride=(1, 1), bias=False)
            (1): BatchNorm2d(320, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
          )
        )
        (stochastic_depth): StochasticDepth(p=0.1875, mode=row)
      )
    )
    (8): Conv2dNormActivation(
      (0): Conv2d(320, 1280, kernel_size=(1, 1), stride=(1, 1), bias=False)
      (1): BatchNorm2d(1280, eps=1e-05, momentum=0.1, affine=True, track_running_stats=True)
      (2): SiLU(inplace=True)
    )
  )
  (1): AdaptiveAvgPool2d(output_size=1)
)
```

```
  (global_avg_pool): AdaptiveAvgPool2d(output_size=1)
  (gru): GRU(1280, 128, batch_first=True)
  (fc): Linear(in_features=128, out_features=1, bias=True)
  (dropout): Dropout(p=0.5, inplace=False)
  (sigmoid): Sigmoid()
)
```

```python
# Define la función para preprocesar las imágenes para VGG16 y CombinedModel
def preprocess_image_for_combined_model(image):
    # Transformaciones para preprocesar las imágenes para VGG16
    transform = transforms.Compose([
        transforms.Resize((224, 224)),  # Cambiar el tamaño a 224x224 (tamaño de entrada de la VG
        transforms.ToTensor(),  # Convertir a tensor
        transforms.Normalize(mean=[0.485, 0.456, 0.406], std=[0.229, 0.224, 0.225])  # Normalizac
    ])

    preprocessed_image = transform(image)  # Aplica las transformaciones
    return preprocessed_image
```

```python
def apply_PCA(images):
    images_flat = images.reshape(images.shape[0], -1).numpy()  # Aplanar y convertir a numpy
    pca = PCA(n_components=70)  # Instanciar PCA
    transformed = pca.fit_transform(images_flat)  # Aplicar PCA
    return transformed
```

```python
class ImageDataGenerator:
    def __init__(self, df, ct_folder, max_samples, cervical, vertebrae_info, batch_size=32):
        self.df = df
        self.ct_folder = ct_folder
        self.batch_size = batch_size
        self.num_samples = len(df)
        self.current_idx = 0
        self.cervical = cervical
        self.vertebrae_info = vertebrae_info
        self.max_samples = max_samples

    def __iter__(self):
        return self

    def __next__(self):
        # batch_images = []
        # batch_labels = []
        batch_images = torch.zeros((self.batch_size, self.max_samples, 3, 224, 224))
        batch_labels = torch.zeros((self.batch_size, 1))
        max_length = self.max_samples
        for i in range(self.batch_size):
            if self.current_idx >= self.num_samples:
```

```
                self.current_idx = 0
                raise StopIteration

            ct_name = self.df.iloc[self.current_idx]['StudyInstanceUID']
            labels = [float(self.df.iloc[self.current_idx]['C' + str(self.cervical)])]
            filas_seleccionadas = self.vertebrae_info.loc[(self.vertebrae_info['StudyInstanceUID'
            # labels = self.df.iloc[self.current_idx][['C1', 'C2', 'C3', 'C4', 'C5', 'C6', 'C7']]
            if not filas_seleccionadas.empty:
                slice_numbers = filas_seleccionadas['Slice'].tolist()
                with ZipFile(os.path.join(self.ct_folder, ct_name + '.zip'), 'r') as zip_ref:
                    image_files = zip_ref.namelist()

                    # Read and process each image
                    ct_images = []
                    counter = 0
                    for image_file in image_files:
                        slice_number = int(image_file.split('.jpg')[0].split('/')[-1])
                        if slice_number in slice_numbers:
                            with zip_ref.open(image_file) as img_file:
                                image = Image.open(img_file)  # Load the image
                                image = preprocess_image_for_combined_model(image)
                                # ct_images.append(image)
                                batch_images[i, counter] = image
                            counter += 1
                            if counter == max_length:
                                break
                    # ct_images = apply_PCA(torch.stack(ct_images))
                    # print(ct_images.shape)
                    while counter < max_length:
                        # ct_images.append(torch.zeros(3, 224, 224))
                        batch_images[i, counter] = torch.zeros(3, 224, 224)
                        counter += 1
                    # Append images and labels to the batch=
                    # batch_images.append(ct_images)

                    # batch_labels.append(labels)
            batch_labels[i] = torch.tensor(labels)
            self.current_idx += 1
        # for el in batch_images:
        #     for el2 in el:
        #         print(type(el2))
        # batch_images = np.array(batch_images)
        # batch_labels = np.array(batch_labels)
        return batch_images, batch_labels

    def __len__(self):
        # Devuelve la longitud total del generador
        return self.num_samples
```

```
batch_size = 1
```

```
data_generator = ImageDataGenerator(train_data, 'imagenes_train', 80, 6, data_vertebrae, batch_si
data_generator_test = ImageDataGenerator(test_data, 'imagenes_train', 80, 6, data_vertebrae, batcl
```

```
# Especifica la carpeta donde se almacenarán los registros de TensorBoard
log_dir = "logs"

# Inicializa TensorBoard
writer = SummaryWriter(log_dir=os.path.join(log_dir, 'loss'))
accuracy_writer = SummaryWriter(log_dir=os.path.join(log_dir, 'accuracy'))
F1_writer = SummaryWriter(log_dir=os.path.join(log_dir, 'F1'))
```

```
# Hiperparámetros de entrenamiento
learning_rate = 0.001
num_epochs = 10  # Número de épocas (iteraciones completas sobre el conjunto de datos)
display_step = 8
accumulation_steps = 4
# Suponiendo que `data_generator` es la instancia del generador de datos que creamos antes

# Definir la función de pérdida y el optimizador
# criterion = WeightedMultiLabelLogLoss()  # Suponiendo una tarea de clasificación
criterion = nn.BCELoss()
optimizer = optim.Adam(combined_model.parameters(), lr=learning_rate)

# Entrenamiento del modelo
combined_model.train()  # Poner el modelo en modo de entrenamiento
loss_list = []
accuracy_list = []
F1_list = []

for epoch in range(num_epochs):
    total_loss = 0.0
    total_accuracy = 0.0
    running_loss = 0.0
    counter = 0
    running_accuracy = 0.0
    F1_acum = 0.0
    running_F1 = 0.0
    total_F1 = 0.0
    loss_acum = 0.0
    optimizer.zero_grad()  # Reiniciar los gradientes acumulados
    # Iterar a través del generador en mini lotes
    for i, (images_tensor, labels_tensor) in tqdm(enumerate(data_generator), total=len(data_genera
    # for i, (images_tensor, labels_tensor) in enumerate(data_generator):
        # print(i)
        # Convertir el lote de imágenes a tensores y pasarlos por el modelo
```

```
        # try:
        torch.cuda.empty_cache()
        images_tensor = images_tensor.to('cuda')
        labels_tensor = labels_tensor.to('cuda')
        # Realizar la propagación hacia adelante (forward pass)
        predictions = combined_model(images_tensor)
        # print(predictions, labels_batch)
        # predictions = torch.mean(predictions, dim=0, keepdim=False)
        loss = criterion(predictions, labels_tensor)
        threshold = 0.5
        predicted_labels = (predictions > threshold).float()  # 1 si es mayor al umbral, 0 de lo 
        predicted_labels_np = predicted_labels.cpu().numpy()

        # print(predictions)
        # Calcular la precisión
        correct_batch = (predicted_labels == labels_tensor).all(dim=1).sum().item()
        total_accuracy += correct_batch
        running_accuracy += correct_batch

        # Calcular F1
        running_F1 += f1_score(labels_tensor.cpu().numpy(), predicted_labels_np, average='weighte
        F1_acum += f1_score(labels_tensor.cpu().numpy(), predicted_labels_np, average='weighted')
        total_F1 += f1_score(labels_tensor.cpu().numpy(), predicted_labels_np, average='weighted'


        if (i + 1) % accumulation_steps == 0 or i == len(data_generator) - 1:
            loss.backward()
            optimizer.step()  # Actualizar los pesos


        # Acumular la pérdida total
        total_loss += loss.item()
        running_loss += loss.item()
        # total_accuracy += accuracy

        # Actualizar la pérdida en tiempo real en TensorBoard
        if i % display_step == display_step - 1:
            avg_loss = running_loss / display_step
            writer.add_scalar('Loss', avg_loss, epoch * len(data_generator) + i)

            running_loss = 0.0

        # Actualizar la precisión en tiempo real en TensorBoard
        if i % display_step == display_step - 1:
            avg_accuracy = running_accuracy / display_step
            accuracy_writer.add_scalar('Accuracy', avg_accuracy, epoch * len(data_generator) + i)
            running_accuracy = 0.0

        # Actualizar la precisión en tiempo real en TensorBoard
        if i % display_step == display_step - 1:
            avg_F1 = running_F1 / display_step
```

```
            F1_writer.add_scalar('F1', avg_F1, epoch * len(data_generator) + i)
            running_F1 = 0.0

        # except:
        #     print("error")
        #     continue

        # if i % display_step == display_step - 1:
        #     # print('entre')
        #     avg_loss = running_loss / display_step
        #     writer.add_scalar('Loss', avg_loss, epoch * len(data_generator) + i)
        #     running_loss = 0.0
        counter += 1
        # if counter == 100:
        #     break
    # Calcular la pérdida promedio para la época
    average_loss = total_loss / len(data_generator)
    loss_list.append(average_loss)
    F1_list.append(F1_acum / len(data_generator))
    accuracy_list.append(total_accuracy / len(data_generator))

    print(f'Epoch [{epoch + 1}/{num_epochs}], Loss: {average_loss:.4f}')
    print(f'Accuracy: {total_accuracy / len(data_generator):.4f}')
    print(f'F1: {F1_acum / len(data_generator):.4f}')

print('Entrenamiento completado.')
```

```
  0%|          | 0/480 [00:00<?, ?it/s]

100%|██████████| 480/480 [52:41<00:00,  6.59s/it]

Epoch [1/10], Loss: 0.7559
Accuracy: 0.8583
F1: 0.8583

100%|██████████| 480/480 [48:57<00:00,  6.12s/it]

Epoch [2/10], Loss: 0.8162
Accuracy: 0.8375
F1: 0.8375

100%|██████████| 480/480 [48:48<00:00,  6.10s/it]

Epoch [3/10], Loss: 0.7542
Accuracy: 0.8208
F1: 0.8208

100%|██████████| 480/480 [48:52<00:00,  6.11s/it]
```

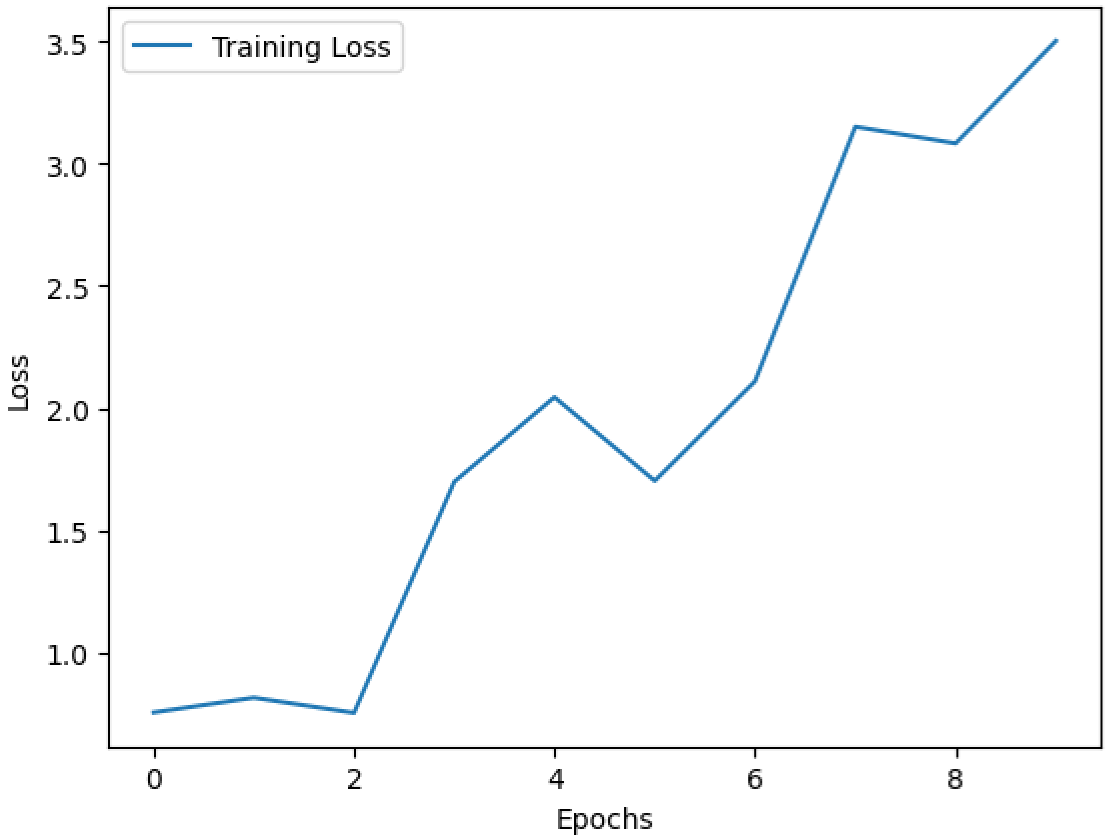
```
Epoch [4/10], Loss: 1.6990
Accuracy: 0.8438
F1: 0.8438

100%|██████████| 480/480 [46:58<00:00,  5.87s/it]

Epoch [5/10], Loss: 2.0450
Accuracy: 0.8688
F1: 0.8688

100%|██████████| 480/480 [46:46<00:00,  5.85s/it]

Epoch [6/10], Loss: 1.7030
Accuracy: 0.7646
F1: 0.7646

100%|██████████| 480/480 [46:45<00:00,  5.84s/it]

Epoch [7/10], Loss: 2.1101
Accuracy: 0.8125
F1: 0.8125

100%|██████████| 480/480 [46:55<00:00,  5.87s/it]

Epoch [8/10], Loss: 3.1510
Accuracy: 0.8688
F1: 0.8688

100%|██████████| 480/480 [46:45<00:00,  5.85s/it]

Epoch [9/10], Loss: 3.0828
Accuracy: 0.8688
F1: 0.8688

100%|██████████| 480/480 [46:50<00:00,  5.86s/it]

Epoch [10/10], Loss: 3.5021
Accuracy: 0.8688
F1: 0.8688
Entrenamiento completado.
```

```python
print(loss_list)
print(F1_list)
print(accuracy_list)
```

```
[0.7559443679196259, 0.816194257804949, 0.7541898255290865, 1.6990159884277545,
2.045001005133757, 1.7029958523413606, 2.11005919107088, 3.1510204792022707, 3.0828415264685947,
3.502082268397013]
[0.8583333333333333, 0.8375, 0.8208333333333333, 0.84375, 0.86875, 0.7645833333333333, 0.8125,
```

```
0.86875, 0.86875, 0.86875]
[0.8583333333333333, 0.8375, 0.8208333333333333, 0.84375, 0.86875, 0.7645833333333333, 0.8125,
0.86875, 0.86875, 0.86875]
```

```
plt.plot(loss_list, label='Training Loss')
plt.xlabel('Epochs')
plt.ylabel('Loss')
plt.legend()
plt.show()
```




```
# Supongamos que ya has entrenado el modelo y deseas guardarlo
torch.save(combined_model.state_dict(), 'modelo_entrenadoC6.pth')
```

```
# Cargar el modelo entrenado
combined_model = CombinedModel(vgg_output_size, gru_hidden_size, gru_num_layers, num_classes)
combined_model.load_state_dict(torch.load('modelo_entrenadoC6.pth'))
```

```
c:\Users\Daniel\Main\UVG\Semestre_VIII\Data_science\Proyecto2\envi\lib\site-
packages\torchvision\models\_utils.py:208: UserWarning: The parameter 'pretrained' is deprecated
since 0.13 and may be removed in the future, please use 'weights' instead.
  warnings.warn(
c:\Users\Daniel\Main\UVG\Semestre_VIII\Data_science\Proyecto2\envi\lib\site-
packages\torchvision\models\_utils.py:223: UserWarning: Arguments other than a weight enum or
`None` for 'weights' are deprecated since 0.13 and may be removed in the future. The current
behavior is equivalent to passing `weights=EfficientNet_B0_Weights.IMAGENET1K_V1`. You can also
```

```
use `weights=EfficientNet_B0_Weights.DEFAULT` to get the most up-to-date weights.
  warnings.warn(msg)
```

```
<All keys matched successfully>
```