```
#import all the necessary libraries for this notebook

#weights and biases
# !pip install wandb --quiet
import wandb
from wandb.keras import WandbCallback

#maths and plotting
import numpy as np
import matplotlib.pyplot as plt

#machine learning
from keras.models import Model
from keras.layers import Input, Conv2D, MaxPooling2D, UpSampling2D,
concatenate, Dropout
from keras.optimizers import adam
from keras.callbacks import EarlyStopping
from keras.metrics import MeanIoU
from sklearn.model_selection import train_test_split

#file system
import os, glob
import tifffile
from tqdm import tqdm

DATA_DIR = '/kaggle/input/leeds-sciml-seaice/sciml'
train_patch_paths = np.array([os.path.basename(i[:-9]) for i in
glob.glob(f'{DATA_DIR}/train/*_sar.tiff')])
test_patch_paths = np.array([os.path.basename(i[:-9]) for i in
glob.glob(f'{DATA_DIR}/test/*_sar.tiff')])

#display patch paths
train_patch_paths
```

```
array(['Patch20190127_133_720_720', 'Patch20191216_17_240_1200',
       'Patch20190104_215_1200_480', ..., 'Patch20190102_28_120_1320',
       'Patch20190104_281_1560_840', 'Patch20190102_182_1320_600'],
      dtype='<U27')
```

```
from tensorflow.keras.utils import Sequence
from tensorflow.keras.preprocessing.image import ImageDataGenerator
from pathlib import Path

def load_img(path):
    img = tifffile.imread(path)
    return img

class DataGenerator(Sequence):
    def __init__(self, patch_paths, data_dir, batch_size,
split='train', augment=False):
        self.patch_paths = patch_paths
```

```
        self.data_dir = Path(data_dir)
        self.batch_size = batch_size
        self.split = split
        self.is_test = split == 'test'
        self.len = len(self.patch_paths) // self.batch_size

    def __len__(self):
        return self.len

    def __getitem__(self, index):
        batch_paths = self.patch_paths[index * self.batch_size:(index
+ 1) * self.batch_size]
        X_sar, X_ms, y = [], [], []

        for patch_path in batch_paths:
            try:
                sar_path = self.data_dir / self.split /
f'{patch_path}_sar.tiff'
                ms_path = self.data_dir / self.split /
f'{patch_path}_vis.tiff'

                sar_arr = load_img(sar_path)
                ms_arr = load_img(ms_path)

                X_sar.append(sar_arr)
                X_ms.append(ms_arr)

                if not self.is_test:
                    label_path = self.data_dir / self.split /
f'{patch_path}_ref.tiff'
                    label_arr = load_img(label_path)
                    y.append(label_arr)

            except FileNotFoundError as fnfe:
                print(f'File not found: {fnfe}')
                continue
            except Exception as e:
                print(f'Unexpected error: {e}')
                raise

        X_sar = np.expand_dims(np.array(X_sar), -1)[:, ::3, ::3, :]
        X_ms = np.array(X_ms)

        if not self.is_test:
            y = np.expand_dims(np.array(y), -1)
            return [X_sar, X_ms], y
        else:
            return [X_sar, X_ms], [None]*len(X_sar)

batch_size = 16
```

```
# Split data into train and test sets
train_patch_paths, val_patch_paths =
train_test_split(train_patch_paths, test_size=0.1, random_state=42)
train_generator = DataGenerator(train_patch_paths, DATA_DIR,
batch_size,augment=True)
val_generator = DataGenerator(val_patch_paths, DATA_DIR, batch_size)
test_generator = DataGenerator(test_patch_paths, DATA_DIR, batch_size,
split='test')

from tensorflow.keras.layers import Input, concatenate, Conv2D,
MaxPooling2D, Dropout, UpSampling2D
from tensorflow.keras.models import Model

def conv_block(input, num_filters):
    x = Conv2D(num_filters, 3, activation='relu', padding='same',
kernel_initializer='he_normal')(input)
    x = Conv2D(num_filters, 3, activation='relu', padding='same',
kernel_initializer='he_normal')(x)
    return x

def unet():
    # Input layers
    input_sar = Input((240, 240, 1))
    input_ms = Input((240, 240, 3))

    # Concatenate inputs
    concat = concatenate([input_sar, input_ms], axis=-1)

    # Encoding path
    conv1 = conv_block(concat, 64)
    pool1 = MaxPooling2D(pool_size=(2, 2))(conv1)

    conv2 = conv_block(pool1, 128)
    pool2 = MaxPooling2D(pool_size=(2, 2))(conv2)

    conv3 = conv_block(pool2, 256)
    pool3 = MaxPooling2D(pool_size=(2, 2))(conv3)

    conv4 = conv_block(pool3, 256)
    drop4 = Dropout(0.5)(conv4)
    pool4 = MaxPooling2D(pool_size=(2, 2))(drop4)

    # Bridge
    conv5 = conv_block(pool4, 512)
    drop5 = Dropout(0.5)(conv5)

    # Decoding path
    up6 = UpSampling2D(size=(2, 2))(drop5)
    up6 = Conv2D(128, 2, activation='relu', padding='same',
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kernel_initializer='he_normal')(up6)
    merge6 = concatenate([drop4, up6], axis=3)
    conv6 = conv_block(merge6, 128)

    up7 = UpSampling2D(size=(2, 2))(conv6)
    up7 = Conv2D(64, 2, activation='relu', padding='same',
kernel_initializer='he_normal')(up7)
    merge7 = concatenate([conv3, up7], axis=3)
    conv7 = conv_block(merge7, 64)

    # Output layers
    output = Conv2D(1, 1, activation='sigmoid')(conv7)
    output = UpSampling2D(size=(4, 4))(output)

    # Model
    model = Model(inputs=[input_sar, input_ms], outputs=output)

    return model

# Create model
model = unet()

import tensorflow as tf
from tensorflow.keras.optimizers.schedules import ExponentialDecay
from tensorflow.keras.optimizers import SGD
from tensorflow.keras.losses import BinaryCrossentropy

initial_learning_rate = 1e-4
lr_schedule = ExponentialDecay(
    initial_learning_rate,
    decay_steps=100000,
    decay_rate=0.96,
    staircase=True)

from tensorflow.keras.optimizers import Adam

optimizer = Adam(learning_rate=lr_schedule)

model.compile(optimizer=optimizer,
              loss=BinaryCrossentropy(from_logits=True),
              metrics=['accuracy',
tf.keras.metrics.MeanIoU(num_classes=2)])

from tensorflow.keras.callbacks import EarlyStopping
import wandb
from wandb.keras import WandbCallback

# Initialize a new W&B run
wandb_enabled = True

# Common arguments
```

```
fit_args = {
    "x": train_generator,
    "validation_data": val_generator,
    "epochs": 100,
    "use_multiprocessing": True,
    "workers": 6,
    "callbacks": [EarlyStopping(patience=10, verbose=1)]
}

if wandb_enabled:
    wandb.init(entity='purge', project='sea-ice-segmentation')
    fit_args["callbacks"].append(WandbCallback())

history = model.fit(**fit_args)

if wandb_enabled:
    wandb.finish()
```

```
<IPython.core.display.HTML object>

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Epoch 1/100

2023-07-03 01:36:06.248143: E
tensorflow/core/grappler/optimizers/meta_optimizer.cc:954] layout
failed: INVALID_ARGUMENT: Size of values 0 does not match size of
permutation 4 @ fanin shape inmodel_2/dropout_6/dropout/SelectV2-2-
TransposeNHWCToNCHW-LayoutOptimizer

79/79 [==============================] - ETA: 0s - loss: 0.5769 -
accuracy: 0.8172 - mean_io_u_2: 0.3044

wandb: Adding directory to artifact (/kaggle/working/wandb/run-
20230703_013513-05awmd6x/files/model-best)... Done. 0.6s

79/79 [==============================] - 38s 374ms/step - loss: 0.5769
- accuracy: 0.8172 - mean_io_u_2: 0.3044 - val_loss: 0.5414 -
val_accuracy: 0.8840 - val_mean_io_u_2: 0.4348
Epoch 2/100
79/79 [==============================] - ETA: 0s - loss: 0.5405 -
accuracy: 0.9057 - mean_io_u_2: 0.5783

wandb: Adding directory to artifact (/kaggle/working/wandb/run-
20230703_013513-05awmd6x/files/model-best)... Done. 0.4s
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```
79/79 [==============================] - 30s 362ms/step - loss: 0.5405
- accuracy: 0.9057 - mean_io_u_2: 0.5783 - val_loss: 0.5323 -
val_accuracy: 0.9044 - val_mean_io_u_2: 0.5853
Epoch 3/100
79/79 [==============================] - ETA: 0s - loss: 0.5331 -
accuracy: 0.9247 - mean_io_u_2: 0.6660

wandb: Adding directory to artifact (/kaggle/working/wandb/run-
20230703_013513-05awmd6x/files/model-best)... Done. 0.3s

79/79 [==============================] - 32s 386ms/step - loss: 0.5331
- accuracy: 0.9247 - mean_io_u_2: 0.6660 - val_loss: 0.5198 -
val_accuracy: 0.9489 - val_mean_io_u_2: 0.7157
Epoch 4/100
79/79 [==============================] - ETA: 0s - loss: 0.5337 -
accuracy: 0.9242 - mean_io_u_2: 0.7084

wandb: Adding directory to artifact (/kaggle/working/wandb/run-
20230703_013513-05awmd6x/files/model-best)... Done. 0.4s

79/79 [==============================] - 32s 368ms/step - loss: 0.5337
- accuracy: 0.9242 - mean_io_u_2: 0.7084 - val_loss: 0.5192 -
val_accuracy: 0.9407 - val_mean_io_u_2: 0.6994
Epoch 5/100
79/79 [==============================] - ETA: 0s - loss: 0.5287 -
accuracy: 0.9354 - mean_io_u_2: 0.7108

wandb: Adding directory to artifact (/kaggle/working/wandb/run-
20230703_013513-05awmd6x/files/model-best)... Done. 0.4s

79/79 [==============================] - 29s 354ms/step - loss: 0.5287
- accuracy: 0.9354 - mean_io_u_2: 0.7108 - val_loss: 0.5154 -
val_accuracy: 0.9548 - val_mean_io_u_2: 0.7232
Epoch 6/100
79/79 [==============================] - 25s 301ms/step - loss: 0.5295
- accuracy: 0.9355 - mean_io_u_2: 0.7229 - val_loss: 0.5158 -
val_accuracy: 0.9552 - val_mean_io_u_2: 0.7495
Epoch 7/100
79/79 [==============================] - 24s 282ms/step - loss: 0.5282
- accuracy: 0.9378 - mean_io_u_2: 0.7262 - val_loss: 0.5221 -
val_accuracy: 0.9322 - val_mean_io_u_2: 0.7008
Epoch 8/100
79/79 [==============================] - ETA: 0s - loss: 0.5279 -
accuracy: 0.9379 - mean_io_u_2: 0.7482

wandb: Adding directory to artifact (/kaggle/working/wandb/run-
20230703_013513-05awmd6x/files/model-best)... Done. 0.4s

79/79 [==============================] - 30s 355ms/step - loss: 0.5279
- accuracy: 0.9379 - mean_io_u_2: 0.7482 - val_loss: 0.5151 -
val_accuracy: 0.9553 - val_mean_io_u_2: 0.7254
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Epoch 9/100
79/79 [==============================] - 25s 292ms/step - loss: 0.5250
- accuracy: 0.9449 - mean_io_u_2: 0.7470 - val_loss: 0.5170 -
val_accuracy: 0.9465 - val_mean_io_u_2: 0.7045
Epoch 10/100
79/79 [==============================] - ETA: 0s - loss: 0.5255 -
accuracy: 0.9433 - mean_io_u_2: 0.7566

wandb: Adding directory to artifact (/kaggle/working/wandb/run-
20230703_013513-05awmd6x/files/model-best)... Done. 0.3s

79/79 [==============================] - 29s 352ms/step - loss: 0.5255
- accuracy: 0.9433 - mean_io_u_2: 0.7566 - val_loss: 0.5146 -
val_accuracy: 0.9545 - val_mean_io_u_2: 0.7594
Epoch 11/100
79/79 [==============================] - ETA: 0s - loss: 0.5255 -
accuracy: 0.9444 - mean_io_u_2: 0.7606

wandb: Adding directory to artifact (/kaggle/working/wandb/run-
20230703_013513-05awmd6x/files/model-best)... Done. 0.4s

79/79 [==============================] - 31s 368ms/step - loss: 0.5255
- accuracy: 0.9444 - mean_io_u_2: 0.7606 - val_loss: 0.5133 -
val_accuracy: 0.9585 - val_mean_io_u_2: 0.7590
Epoch 12/100
79/79 [==============================] - 24s 287ms/step - loss: 0.5274
- accuracy: 0.9386 - mean_io_u_2: 0.7404 - val_loss: 0.5305 -
val_accuracy: 0.9086 - val_mean_io_u_2: 0.7146
Epoch 13/100
79/79 [==============================] - 25s 296ms/step - loss: 0.5266
- accuracy: 0.9418 - mean_io_u_2: 0.7984 - val_loss: 0.5134 -
val_accuracy: 0.9570 - val_mean_io_u_2: 0.7469
Epoch 14/100
79/79 [==============================] - ETA: 0s - loss: 0.5246 -
accuracy: 0.9464 - mean_io_u_2: 0.7962

wandb: Adding directory to artifact (/kaggle/working/wandb/run-
20230703_013513-05awmd6x/files/model-best)... Done. 0.4s

79/79 [==============================] - 29s 348ms/step - loss: 0.5246
- accuracy: 0.9464 - mean_io_u_2: 0.7962 - val_loss: 0.5129 -
val_accuracy: 0.9585 - val_mean_io_u_2: 0.7573
Epoch 15/100
79/79 [==============================] - 25s 296ms/step - loss: 0.5231
- accuracy: 0.9501 - mean_io_u_2: 0.7938 - val_loss: 0.5131 -
val_accuracy: 0.9589 - val_mean_io_u_2: 0.7679
Epoch 16/100
79/79 [==============================] - 22s 253ms/step - loss: 0.5227
- accuracy: 0.9507 - mean_io_u_2: 0.7901 - val_loss: 0.5133 -
val_accuracy: 0.9563 - val_mean_io_u_2: 0.7732
Epoch 17/100
```

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79/79 [==============================] - 25s 291ms/step - loss: 0.5231
- accuracy: 0.9502 - mean_io_u_2: 0.7954 - val_loss: 0.5138 -
val_accuracy: 0.9548 - val_mean_io_u_2: 0.7111
Epoch 18/100
79/79 [==============================] - 25s 300ms/step - loss: 0.5256
- accuracy: 0.9422 - mean_io_u_2: 0.7838 - val_loss: 0.5158 -
val_accuracy: 0.9493 - val_mean_io_u_2: 0.7106
Epoch 19/100
79/79 [==============================] - 24s 288ms/step - loss: 0.5242
- accuracy: 0.9466 - mean_io_u_2: 0.8021 - val_loss: 0.5135 -
val_accuracy: 0.9576 - val_mean_io_u_2: 0.8453
Epoch 20/100
79/79 [==============================] - 25s 305ms/step - loss: 0.5232
- accuracy: 0.9496 - mean_io_u_2: 0.8327 - val_loss: 0.5153 -
val_accuracy: 0.9492 - val_mean_io_u_2: 0.7791
Epoch 21/100
79/79 [==============================] - 25s 297ms/step - loss: 0.5247
- accuracy: 0.9456 - mean_io_u_2: 0.8092 - val_loss: 0.5188 -
val_accuracy: 0.9404 - val_mean_io_u_2: 0.7740
Epoch 22/100
79/79 [==============================] - 24s 293ms/step - loss: 0.5256
- accuracy: 0.9419 - mean_io_u_2: 0.8102 - val_loss: 0.5158 -
val_accuracy: 0.9485 - val_mean_io_u_2: 0.5522
Epoch 23/100
79/79 [==============================] - 25s 294ms/step - loss: 0.5228
- accuracy: 0.9495 - mean_io_u_2: 0.8213 - val_loss: 0.5134 -
val_accuracy: 0.9552 - val_mean_io_u_2: 0.7059
Epoch 24/100
79/79 [==============================] - ETA: 0s - loss: 0.5217 -
accuracy: 0.9527 - mean_io_u_2: 0.8075

wandb: Adding directory to artifact (/kaggle/working/wandb/run-
20230703_013513-05awmd6x/files/model-best)... Done. 0.4s

79/79 [==============================] - 30s 354ms/step - loss: 0.5217
- accuracy: 0.9527 - mean_io_u_2: 0.8075 - val_loss: 0.5124 -
val_accuracy: 0.9598 - val_mean_io_u_2: 0.7614
Epoch 25/100
79/79 [==============================] - 25s 295ms/step - loss: 0.5234
- accuracy: 0.9481 - mean_io_u_2: 0.8049 - val_loss: 0.5173 -
val_accuracy: 0.9439 - val_mean_io_u_2: 0.7101
Epoch 26/100
79/79 [==============================] - ETA: 0s - loss: 0.5243 -
accuracy: 0.9467 - mean_io_u_2: 0.8122

wandb: Adding directory to artifact (/kaggle/working/wandb/run-
20230703_013513-05awmd6x/files/model-best)... Done. 0.3s

79/79 [==============================] - 28s 335ms/step - loss: 0.5243
- accuracy: 0.9467 - mean_io_u_2: 0.8122 - val_loss: 0.5123 -
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val_accuracy: 0.9609 - val_mean_io_u_2: 0.8438
Epoch 27/100
79/79 [==============================] - 25s 290ms/step - loss: 0.5212
- accuracy: 0.9540 - mean_io_u_2: 0.8292 - val_loss: 0.5132 -
val_accuracy: 0.9561 - val_mean_io_u_2: 0.8449
Epoch 28/100
79/79 [==============================] - 24s 290ms/step - loss: 0.5209
- accuracy: 0.9550 - mean_io_u_2: 0.8175 - val_loss: 0.5150 -
val_accuracy: 0.9523 - val_mean_io_u_2: 0.7601
Epoch 29/100
79/79 [==============================] - 24s 287ms/step - loss: 0.5210
- accuracy: 0.9545 - mean_io_u_2: 0.8194 - val_loss: 0.5130 -
val_accuracy: 0.9558 - val_mean_io_u_2: 0.7617
Epoch 30/100
79/79 [==============================] - 24s 286ms/step - loss: 0.5204
- accuracy: 0.9559 - mean_io_u_2: 0.8250 - val_loss: 0.5126 -
val_accuracy: 0.9586 - val_mean_io_u_2: 0.7782
Epoch 31/100
79/79 [==============================] - 25s 298ms/step - loss: 0.5218
- accuracy: 0.9529 - mean_io_u_2: 0.8099 - val_loss: 0.5139 -
val_accuracy: 0.9534 - val_mean_io_u_2: 0.7674
Epoch 32/100
79/79 [==============================] - ETA: 0s - loss: 0.5192 -
accuracy: 0.9589 - mean_io_u_2: 0.8196

wandb: Adding directory to artifact (/kaggle/working/wandb/run-
20230703_013513-05awmd6x/files/model-best)... Done. 0.4s

79/79 [==============================] - 30s 356ms/step - loss: 0.5192
- accuracy: 0.9589 - mean_io_u_2: 0.8196 - val_loss: 0.5118 -
val_accuracy: 0.9600 - val_mean_io_u_2: 0.7341
Epoch 33/100
79/79 [==============================] - ETA: 0s - loss: 0.5192 -
accuracy: 0.9592 - mean_io_u_2: 0.8189

wandb: Adding directory to artifact (/kaggle/working/wandb/run-
20230703_013513-05awmd6x/files/model-best)... Done. 0.4s

79/79 [==============================] - 30s 360ms/step - loss: 0.5192
- accuracy: 0.9592 - mean_io_u_2: 0.8189 - val_loss: 0.5109 -
val_accuracy: 0.9624 - val_mean_io_u_2: 0.7327
Epoch 34/100
79/79 [==============================] - 25s 298ms/step - loss: 0.5194
- accuracy: 0.9583 - mean_io_u_2: 0.8142 - val_loss: 0.5116 -
val_accuracy: 0.9605 - val_mean_io_u_2: 0.6875
Epoch 35/100
79/79 [==============================] - 25s 298ms/step - loss: 0.5185
- accuracy: 0.9602 - mean_io_u_2: 0.8172 - val_loss: 0.5125 -
val_accuracy: 0.9571 - val_mean_io_u_2: 0.8122
Epoch 36/100
```

```
79/79 [==============================] - 25s 292ms/step - loss: 0.5189
- accuracy: 0.9597 - mean_io_u_2: 0.8447 - val_loss: 0.5110 -
val_accuracy: 0.9625 - val_mean_io_u_2: 0.8509
Epoch 37/100
79/79 [==============================] - ETA: 0s - loss: 0.5178 -
accuracy: 0.9619 - mean_io_u_2: 0.8381

wandb: Adding directory to artifact (/kaggle/working/wandb/run-
20230703_013513-05awmd6x/files/model-best)... Done. 0.4s

79/79 [==============================] - 30s 353ms/step - loss: 0.5178
- accuracy: 0.9619 - mean_io_u_2: 0.8381 - val_loss: 0.5100 -
val_accuracy: 0.9657 - val_mean_io_u_2: 0.7784
Epoch 38/100
79/79 [==============================] - 25s 291ms/step - loss: 0.5201
- accuracy: 0.9565 - mean_io_u_2: 0.8310 - val_loss: 0.5111 -
val_accuracy: 0.9628 - val_mean_io_u_2: 0.8599
Epoch 39/100
79/79 [==============================] - 25s 296ms/step - loss: 0.5177
- accuracy: 0.9620 - mean_io_u_2: 0.8581 - val_loss: 0.5100 -
val_accuracy: 0.9639 - val_mean_io_u_2: 0.8232
Epoch 40/100
79/79 [==============================] - 24s 291ms/step - loss: 0.5172
- accuracy: 0.9635 - mean_io_u_2: 0.8437 - val_loss: 0.5103 -
val_accuracy: 0.9651 - val_mean_io_u_2: 0.8413
Epoch 41/100
79/79 [==============================] - 24s 289ms/step - loss: 0.5182
- accuracy: 0.9613 - mean_io_u_2: 0.8403 - val_loss: 0.5105 -
val_accuracy: 0.9649 - val_mean_io_u_2: 0.8344
Epoch 42/100
79/79 [==============================] - 24s 289ms/step - loss: 0.5189
- accuracy: 0.9594 - mean_io_u_2: 0.8421 - val_loss: 0.5106 -
val_accuracy: 0.9636 - val_mean_io_u_2: 0.7346
Epoch 43/100
79/79 [==============================] - 25s 305ms/step - loss: 0.5170
- accuracy: 0.9634 - mean_io_u_2: 0.8371 - val_loss: 0.5162 -
val_accuracy: 0.9472 - val_mean_io_u_2: 0.7992
Epoch 44/100
79/79 [==============================] - 25s 300ms/step - loss: 0.5183
- accuracy: 0.9605 - mean_io_u_2: 0.8608 - val_loss: 0.5103 -
val_accuracy: 0.9645 - val_mean_io_u_2: 0.8176
Epoch 45/100
79/79 [==============================] - ETA: 0s - loss: 0.5167 -
accuracy: 0.9644 - mean_io_u_2: 0.8583

wandb: Adding directory to artifact (/kaggle/working/wandb/run-
20230703_013513-05awmd6x/files/model-best)... Done. 0.3s

79/79 [==============================] - 30s 357ms/step - loss: 0.5167
- accuracy: 0.9644 - mean_io_u_2: 0.8583 - val_loss: 0.5099 -
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val_accuracy: 0.9646 - val_mean_io_u_2: 0.8821
Epoch 46/100
79/79 [==============================] - 25s 295ms/step - loss: 0.5160
- accuracy: 0.9662 - mean_io_u_2: 0.8680 - val_loss: 0.5104 -
val_accuracy: 0.9629 - val_mean_io_u_2: 0.8465
Epoch 47/100
79/79 [==============================] - ETA: 0s - loss: 0.5153 -
accuracy: 0.9676 - mean_io_u_2: 0.8659

wandb: Adding directory to artifact (/kaggle/working/wandb/run-
20230703_013513-05awmd6x/files/model-best)... Done. 0.4s

79/79 [==============================] - 30s 361ms/step - loss: 0.5153
- accuracy: 0.9676 - mean_io_u_2: 0.8659 - val_loss: 0.5091 -
val_accuracy: 0.9658 - val_mean_io_u_2: 0.8481
Epoch 48/100
79/79 [==============================] - 25s 298ms/step - loss: 0.5161
- accuracy: 0.9660 - mean_io_u_2: 0.8728 - val_loss: 0.5100 -
val_accuracy: 0.9663 - val_mean_io_u_2: 0.8735
Epoch 49/100
79/79 [==============================] - 25s 298ms/step - loss: 0.5155
- accuracy: 0.9672 - mean_io_u_2: 0.8696 - val_loss: 0.5093 -
val_accuracy: 0.9673 - val_mean_io_u_2: 0.8357
Epoch 50/100
79/79 [==============================] - 25s 293ms/step - loss: 0.5167
- accuracy: 0.9644 - mean_io_u_2: 0.8718 - val_loss: 0.5132 -
val_accuracy: 0.9540 - val_mean_io_u_2: 0.8294
Epoch 51/100
79/79 [==============================] - 24s 293ms/step - loss: 0.5210
- accuracy: 0.9537 - mean_io_u_2: 0.8680 - val_loss: 0.5115 -
val_accuracy: 0.9592 - val_mean_io_u_2: 0.8249
Epoch 52/100
79/79 [==============================] - 24s 284ms/step - loss: 0.5163
- accuracy: 0.9651 - mean_io_u_2: 0.8803 - val_loss: 0.5099 -
val_accuracy: 0.9632 - val_mean_io_u_2: 0.7974
Epoch 53/100
79/79 [==============================] - 25s 295ms/step - loss: 0.5149
- accuracy: 0.9685 - mean_io_u_2: 0.8844 - val_loss: 0.5091 -
val_accuracy: 0.9656 - val_mean_io_u_2: 0.8228
Epoch 54/100
79/79 [==============================] - 24s 289ms/step - loss: 0.5142
- accuracy: 0.9702 - mean_io_u_2: 0.8880 - val_loss: 0.5092 -
val_accuracy: 0.9651 - val_mean_io_u_2: 0.8501
Epoch 55/100
79/79 [==============================] - 24s 281ms/step - loss: 0.5149
- accuracy: 0.9685 - mean_io_u_2: 0.8839 - val_loss: 0.5179 -
val_accuracy: 0.9544 - val_mean_io_u_2: 0.8940
Epoch 56/100
79/79 [==============================] - 25s 294ms/step - loss: 0.5178
- accuracy: 0.9618 - mean_io_u_2: 0.8789 - val_loss: 0.5091 -
```

```
val_accuracy: 0.9657 - val_mean_io_u_2: 0.8605
Epoch 57/100
79/79 [==============================] - ETA: 0s - loss: 0.5145 -
accuracy: 0.9692 - mean_io_u_2: 0.8899

wandb: Adding directory to artifact (/kaggle/working/wandb/run-
20230703_013513-05awmd6x/files/model-best)... Done. 0.4s

79/79 [==============================] - 29s 351ms/step - loss: 0.5145
- accuracy: 0.9692 - mean_io_u_2: 0.8899 - val_loss: 0.5085 -
val_accuracy: 0.9673 - val_mean_io_u_2: 0.8144
Epoch 58/100
79/79 [==============================] - ETA: 0s - loss: 0.5137 -
accuracy: 0.9712 - mean_io_u_2: 0.8968

wandb: Adding directory to artifact (/kaggle/working/wandb/run-
20230703_013513-05awmd6x/files/model-best)... Done. 0.3s

79/79 [==============================] - 29s 347ms/step - loss: 0.5137
- accuracy: 0.9712 - mean_io_u_2: 0.8968 - val_loss: 0.5080 -
val_accuracy: 0.9691 - val_mean_io_u_2: 0.8883
Epoch 59/100
79/79 [==============================] - 25s 287ms/step - loss: 0.5140
- accuracy: 0.9702 - mean_io_u_2: 0.8916 - val_loss: 0.5097 -
val_accuracy: 0.9667 - val_mean_io_u_2: 0.9120
Epoch 60/100
79/79 [==============================] - 26s 299ms/step - loss: 0.5147
- accuracy: 0.9690 - mean_io_u_2: 0.8965 - val_loss: 0.5109 -
val_accuracy: 0.9640 - val_mean_io_u_2: 0.8890
Epoch 61/100
79/79 [==============================] - 25s 298ms/step - loss: 0.5163
- accuracy: 0.9651 - mean_io_u_2: 0.8846 - val_loss: 0.5109 -
val_accuracy: 0.9616 - val_mean_io_u_2: 0.8891
Epoch 62/100
79/79 [==============================] - ETA: 0s - loss: 0.5154 -
accuracy: 0.9671 - mean_io_u_2: 0.8895

wandb: Adding directory to artifact (/kaggle/working/wandb/run-
20230703_013513-05awmd6x/files/model-best)... Done. 0.4s

79/79 [==============================] - 30s 355ms/step - loss: 0.5154
- accuracy: 0.9671 - mean_io_u_2: 0.8895 - val_loss: 0.5077 -
val_accuracy: 0.9691 - val_mean_io_u_2: 0.8983
Epoch 63/100
79/79 [==============================] - ETA: 0s - loss: 0.5135 -
accuracy: 0.9717 - mean_io_u_2: 0.9105

wandb: Adding directory to artifact (/kaggle/working/wandb/run-
20230703_013513-05awmd6x/files/model-best)... Done. 0.3s
```

```
79/79 [==============================] - 30s 360ms/step - loss: 0.5135
- accuracy: 0.9717 - mean_io_u_2: 0.9105 - val_loss: 0.5077 -
val_accuracy: 0.9705 - val_mean_io_u_2: 0.9058
Epoch 64/100
79/79 [==============================] - 26s 303ms/step - loss: 0.5169
- accuracy: 0.9624 - mean_io_u_2: 0.8945 - val_loss: 0.5083 -
val_accuracy: 0.9673 - val_mean_io_u_2: 0.8805
Epoch 65/100
79/79 [==============================] - 24s 289ms/step - loss: 0.5144
- accuracy: 0.9694 - mean_io_u_2: 0.8994 - val_loss: 0.5089 -
val_accuracy: 0.9656 - val_mean_io_u_2: 0.8570
Epoch 66/100
79/79 [==============================] - ETA: 0s - loss: 0.5132 -
accuracy: 0.9723 - mean_io_u_2: 0.9101

wandb: Adding directory to artifact (/kaggle/working/wandb/run-
20230703_013513-05awmd6x/files/model-best)... Done. 0.3s

79/79 [==============================] - 30s 365ms/step - loss: 0.5132
- accuracy: 0.9723 - mean_io_u_2: 0.9101 - val_loss: 0.5061 -
val_accuracy: 0.9708 - val_mean_io_u_2: 0.8721
Epoch 67/100
79/79 [==============================] - 25s 293ms/step - loss: 0.5125
- accuracy: 0.9727 - mean_io_u_2: 0.9088 - val_loss: 0.5076 -
val_accuracy: 0.9710 - val_mean_io_u_2: 0.9110
Epoch 68/100
79/79 [==============================] - 24s 289ms/step - loss: 0.5137
- accuracy: 0.9710 - mean_io_u_2: 0.9108 - val_loss: 0.5080 -
val_accuracy: 0.9695 - val_mean_io_u_2: 0.8955
Epoch 69/100
79/79 [==============================] - 25s 301ms/step - loss: 0.5147
- accuracy: 0.9686 - mean_io_u_2: 0.9026 - val_loss: 0.5080 -
val_accuracy: 0.9685 - val_mean_io_u_2: 0.8726
Epoch 70/100
79/79 [==============================] - 25s 293ms/step - loss: 0.5127
- accuracy: 0.9729 - mean_io_u_2: 0.9130 - val_loss: 0.5067 -
val_accuracy: 0.9721 - val_mean_io_u_2: 0.9153
Epoch 71/100
79/79 [==============================] - ETA: 0s - loss: 0.5115 -
accuracy: 0.9751 - mean_io_u_2: 0.9178

wandb: Adding directory to artifact (/kaggle/working/wandb/run-
20230703_013513-05awmd6x/files/model-best)... Done. 0.4s

79/79 [==============================] - 29s 346ms/step - loss: 0.5115
- accuracy: 0.9751 - mean_io_u_2: 0.9178 - val_loss: 0.5054 -
val_accuracy: 0.9734 - val_mean_io_u_2: 0.8878
Epoch 72/100
79/79 [==============================] - 26s 293ms/step - loss: 0.5112
- accuracy: 0.9759 - mean_io_u_2: 0.9137 - val_loss: 0.5058 -
```

```
val_accuracy: 0.9734 - val_mean_io_u_2: 0.8907
Epoch 73/100
79/79 [==============================] - ETA: 0s - loss: 0.5108 -
accuracy: 0.9763 - mean_io_u_2: 0.9150

wandb: Adding directory to artifact (/kaggle/working/wandb/run-
20230703_013513-05awmd6x/files/model-best)... Done. 0.4s

79/79 [==============================] - 30s 363ms/step - loss: 0.5108
- accuracy: 0.9763 - mean_io_u_2: 0.9150 - val_loss: 0.5049 -
val_accuracy: 0.9741 - val_mean_io_u_2: 0.9074
Epoch 74/100
79/79 [==============================] - 25s 296ms/step - loss: 0.5120
- accuracy: 0.9750 - mean_io_u_2: 0.9195 - val_loss: 0.5067 -
val_accuracy: 0.9717 - val_mean_io_u_2: 0.9007
Epoch 75/100
79/79 [==============================] - ETA: 0s - loss: 0.5117 -
accuracy: 0.9753 - mean_io_u_2: 0.9101

wandb: Adding directory to artifact (/kaggle/working/wandb/run-
20230703_013513-05awmd6x/files/model-best)... Done. 0.3s

79/79 [==============================] - 29s 350ms/step - loss: 0.5117
- accuracy: 0.9753 - mean_io_u_2: 0.9101 - val_loss: 0.5043 -
val_accuracy: 0.9757 - val_mean_io_u_2: 0.9073
Epoch 76/100
79/79 [==============================] - ETA: 0s - loss: 0.5105 -
accuracy: 0.9772 - mean_io_u_2: 0.9207

wandb: Adding directory to artifact (/kaggle/working/wandb/run-
20230703_013513-05awmd6x/files/model-best)... Done. 0.3s

79/79 [==============================] - 33s 400ms/step - loss: 0.5105
- accuracy: 0.9772 - mean_io_u_2: 0.9207 - val_loss: 0.5042 -
val_accuracy: 0.9757 - val_mean_io_u_2: 0.8899
Epoch 77/100
79/79 [==============================] - 25s 290ms/step - loss: 0.5108
- accuracy: 0.9765 - mean_io_u_2: 0.9168 - val_loss: 0.5066 -
val_accuracy: 0.9701 - val_mean_io_u_2: 0.8619
Epoch 78/100
79/79 [==============================] - 25s 293ms/step - loss: 0.5140
- accuracy: 0.9689 - mean_io_u_2: 0.9023 - val_loss: 0.5086 -
val_accuracy: 0.9646 - val_mean_io_u_2: 0.8888
Epoch 79/100
79/79 [==============================] - 24s 287ms/step - loss: 0.5115
- accuracy: 0.9746 - mean_io_u_2: 0.9041 - val_loss: 0.5047 -
val_accuracy: 0.9746 - val_mean_io_u_2: 0.9003
Epoch 80/100
79/79 [==============================] - 25s 300ms/step - loss: 0.5097
- accuracy: 0.9789 - mean_io_u_2: 0.9238 - val_loss: 0.5043 -
val_accuracy: 0.9756 - val_mean_io_u_2: 0.9079
```

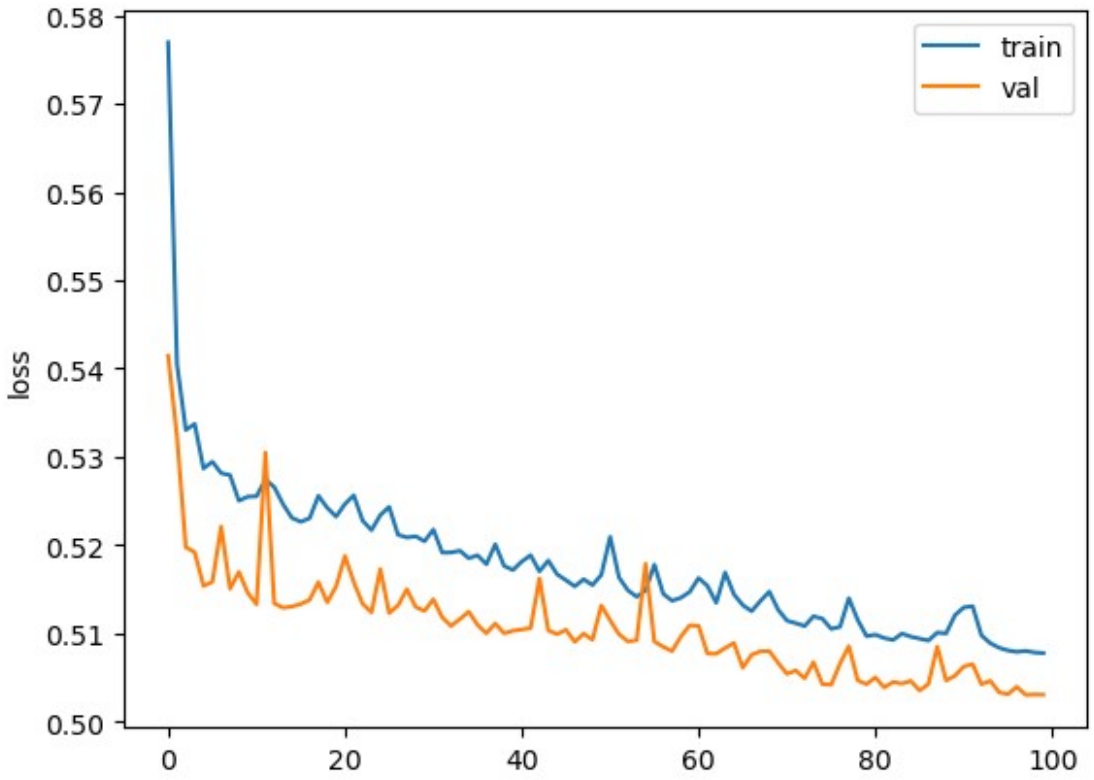
```
Epoch 81/100
79/79 [==============================] - 24s 293ms/step - loss: 0.5099
- accuracy: 0.9787 - mean_io_u_2: 0.9275 - val_loss: 0.5050 -
val_accuracy: 0.9728 - val_mean_io_u_2: 0.8895
Epoch 82/100
79/79 [==============================] - ETA: 0s - loss: 0.5095 -
accuracy: 0.9794 - mean_io_u_2: 0.9283

wandb: Adding directory to artifact (/kaggle/working/wandb/run-
20230703_013513-05awmd6x/files/model-best)... Done. 0.4s

79/79 [==============================] - 31s 372ms/step - loss: 0.5095
- accuracy: 0.9794 - mean_io_u_2: 0.9283 - val_loss: 0.5039 -
val_accuracy: 0.9765 - val_mean_io_u_2: 0.9081
Epoch 83/100
79/79 [==============================] - 25s 303ms/step - loss: 0.5093
- accuracy: 0.9798 - mean_io_u_2: 0.9312 - val_loss: 0.5045 -
val_accuracy: 0.9745 - val_mean_io_u_2: 0.8997
Epoch 84/100
79/79 [==============================] - 25s 291ms/step - loss: 0.5100
- accuracy: 0.9787 - mean_io_u_2: 0.9270 - val_loss: 0.5043 -
val_accuracy: 0.9747 - val_mean_io_u_2: 0.9062
Epoch 85/100
79/79 [==============================] - 25s 292ms/step - loss: 0.5096
- accuracy: 0.9792 - mean_io_u_2: 0.9275 - val_loss: 0.5046 -
val_accuracy: 0.9752 - val_mean_io_u_2: 0.9013
Epoch 86/100
79/79 [==============================] - ETA: 0s - loss: 0.5094 -
accuracy: 0.9796 - mean_io_u_2: 0.9305

wandb: Adding directory to artifact (/kaggle/working/wandb/run-
20230703_013513-05awmd6x/files/model-best)... Done. 0.3s

79/79 [==============================] - 29s 349ms/step - loss: 0.5094
- accuracy: 0.9796 - mean_io_u_2: 0.9305 - val_loss: 0.5036 -
val_accuracy: 0.9773 - val_mean_io_u_2: 0.9020
Epoch 87/100
79/79 [==============================] - 25s 294ms/step - loss: 0.5092
- accuracy: 0.9800 - mean_io_u_2: 0.9308 - val_loss: 0.5043 -
val_accuracy: 0.9772 - val_mean_io_u_2: 0.9272
Epoch 88/100
79/79 [==============================] - 25s 295ms/step - loss: 0.5101
- accuracy: 0.9779 - mean_io_u_2: 0.9246 - val_loss: 0.5085 -
val_accuracy: 0.9645 - val_mean_io_u_2: 0.8925
Epoch 89/100
79/79 [==============================] - 24s 288ms/step - loss: 0.5100
- accuracy: 0.9782 - mean_io_u_2: 0.9217 - val_loss: 0.5047 -
val_accuracy: 0.9753 - val_mean_io_u_2: 0.8967
Epoch 90/100
79/79 [==============================] - 25s 298ms/step - loss: 0.5121
```

```
- accuracy: 0.9731 - mean_io_u_2: 0.9137 - val_loss: 0.5052 -
val_accuracy: 0.9732 - val_mean_io_u_2: 0.9103
Epoch 91/100
79/79 [==============================] - 25s 296ms/step - loss: 0.5130
- accuracy: 0.9714 - mean_io_u_2: 0.9159 - val_loss: 0.5063 -
val_accuracy: 0.9711 - val_mean_io_u_2: 0.9095
Epoch 92/100
79/79 [==============================] - 24s 291ms/step - loss: 0.5131
- accuracy: 0.9718 - mean_io_u_2: 0.9214 - val_loss: 0.5065 -
val_accuracy: 0.9726 - val_mean_io_u_2: 0.9308
Epoch 93/100
79/79 [==============================] - 24s 294ms/step - loss: 0.5098
- accuracy: 0.9788 - mean_io_u_2: 0.9334 - val_loss: 0.5043 -
val_accuracy: 0.9755 - val_mean_io_u_2: 0.8985
Epoch 94/100
79/79 [==============================] - 25s 294ms/step - loss: 0.5089
- accuracy: 0.9807 - mean_io_u_2: 0.9333 - val_loss: 0.5046 -
val_accuracy: 0.9761 - val_mean_io_u_2: 0.9214
Epoch 95/100
79/79 [==============================] - ETA: 0s - loss: 0.5084 -
accuracy: 0.9820 - mean_io_u_2: 0.9392

wandb: Adding directory to artifact (/kaggle/working/wandb/run-
20230703_013513-05awmd6x/files/model-best)... Done. 0.4s

79/79 [==============================] - 30s 366ms/step - loss: 0.5084
- accuracy: 0.9820 - mean_io_u_2: 0.9392 - val_loss: 0.5033 -
val_accuracy: 0.9784 - val_mean_io_u_2: 0.9231
Epoch 96/100
79/79 [==============================] - ETA: 0s - loss: 0.5081 -
accuracy: 0.9827 - mean_io_u_2: 0.9421

wandb: Adding directory to artifact (/kaggle/working/wandb/run-
20230703_013513-05awmd6x/files/model-best)... Done. 0.4s

79/79 [==============================] - 32s 380ms/step - loss: 0.5081
- accuracy: 0.9827 - mean_io_u_2: 0.9421 - val_loss: 0.5031 -
val_accuracy: 0.9790 - val_mean_io_u_2: 0.9229
Epoch 97/100
79/79 [==============================] - 25s 305ms/step - loss: 0.5079
- accuracy: 0.9831 - mean_io_u_2: 0.9427 - val_loss: 0.5040 -
val_accuracy: 0.9776 - val_mean_io_u_2: 0.9280
Epoch 98/100
79/79 [==============================] - ETA: 0s - loss: 0.5080 -
accuracy: 0.9829 - mean_io_u_2: 0.9428

wandb: Adding directory to artifact (/kaggle/working/wandb/run-
20230703_013513-05awmd6x/files/model-best)... Done. 0.3s

79/79 [==============================] - 30s 365ms/step - loss: 0.5080
- accuracy: 0.9829 - mean_io_u_2: 0.9428 - val_loss: 0.5031 -
```

```
val_accuracy: 0.9787 - val_mean_io_u_2: 0.9081
Epoch 99/100
79/79 [==============================] - 26s 300ms/step - loss: 0.5079
- accuracy: 0.9833 - mean_io_u_2: 0.9402 - val_loss: 0.5031 -
val_accuracy: 0.9789 - val_mean_io_u_2: 0.9246
Epoch 100/100
79/79 [==============================] - 25s 300ms/step - loss: 0.5078
- accuracy: 0.9835 - mean_io_u_2: 0.9421 - val_loss: 0.5031 -
val_accuracy: 0.9795 - val_mean_io_u_2: 0.9263

<IPython.core.display.HTML object>

<IPython.core.display.HTML object>

<IPython.core.display.HTML object>

<IPython.core.display.HTML object>
```

```
#@title Now plot the results of the training run:

metric_to_plot = 'loss' #@param ['loss', 'accuracy', 'mean_io_u']

ys = history.history[metric_to_plot]
ys_val = history.history['val_'+metric_to_plot]
num_epochs = len(ys)
plt.plot(range(num_epochs), ys, label='train')
plt.plot(range(num_epochs), ys_val, label='val')
plt.legend()
plt.ylabel(metric_to_plot)
```

```
Text(0, 0.5, 'loss')
```



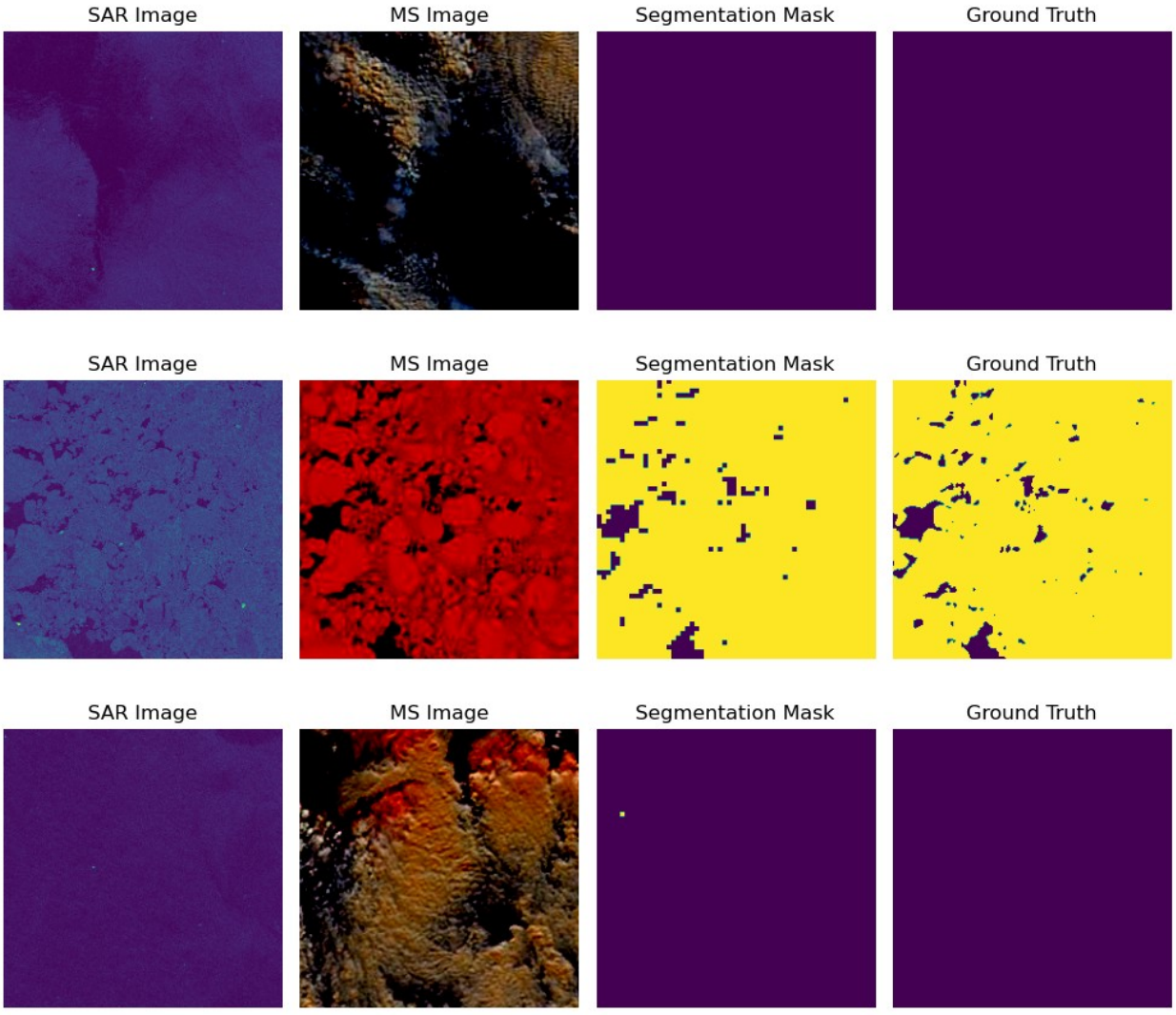

```
#@markdown You need to specify the threshold value, which determines
the threshold for classifying pixels as foreground or background.
Adjusting this value may affect the performance of the segmentation.

threshold = 0.5 #@param {type:"slider", min:0, max:1, step:0.1}
threshold
```

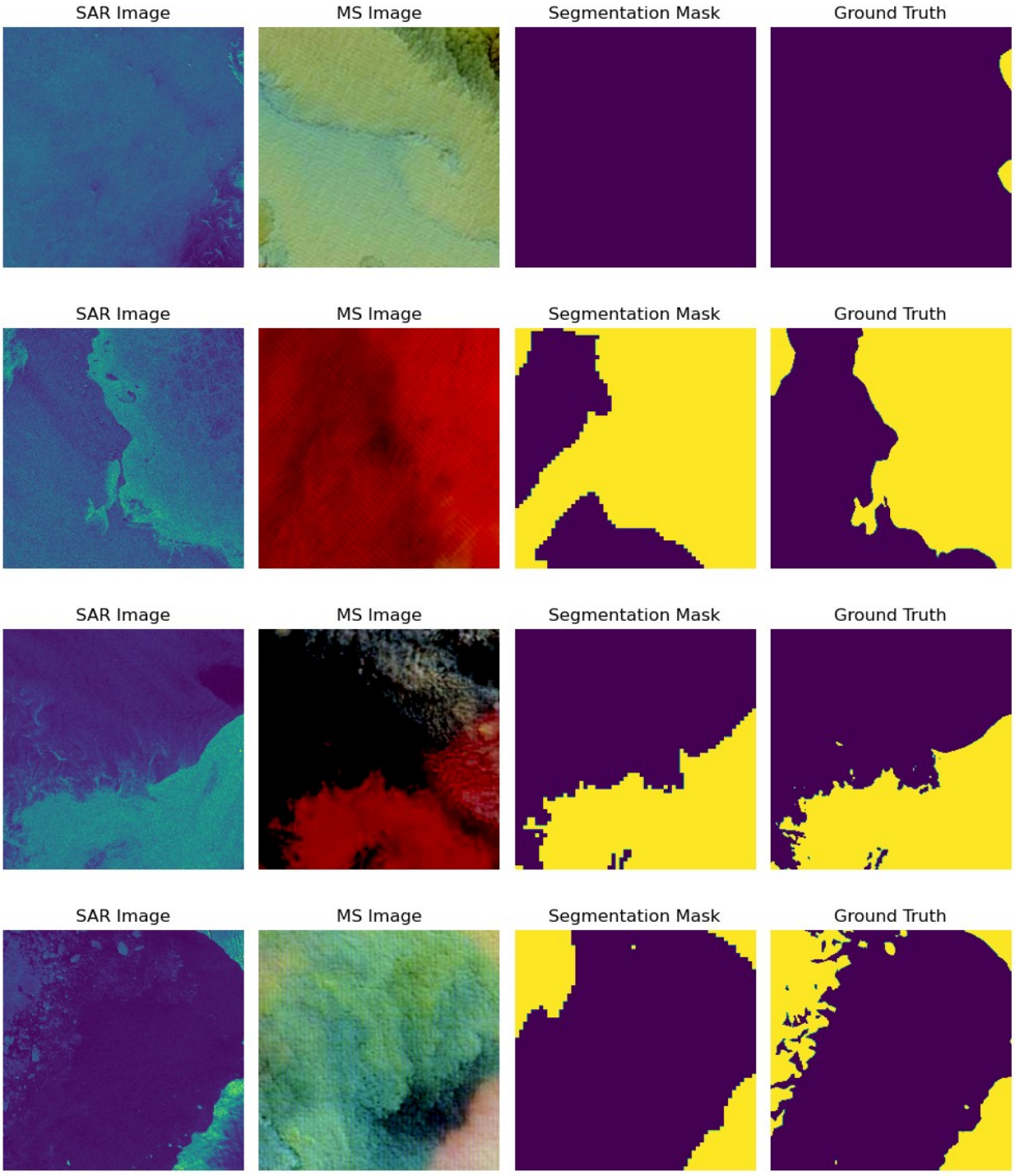
```
0.5
```

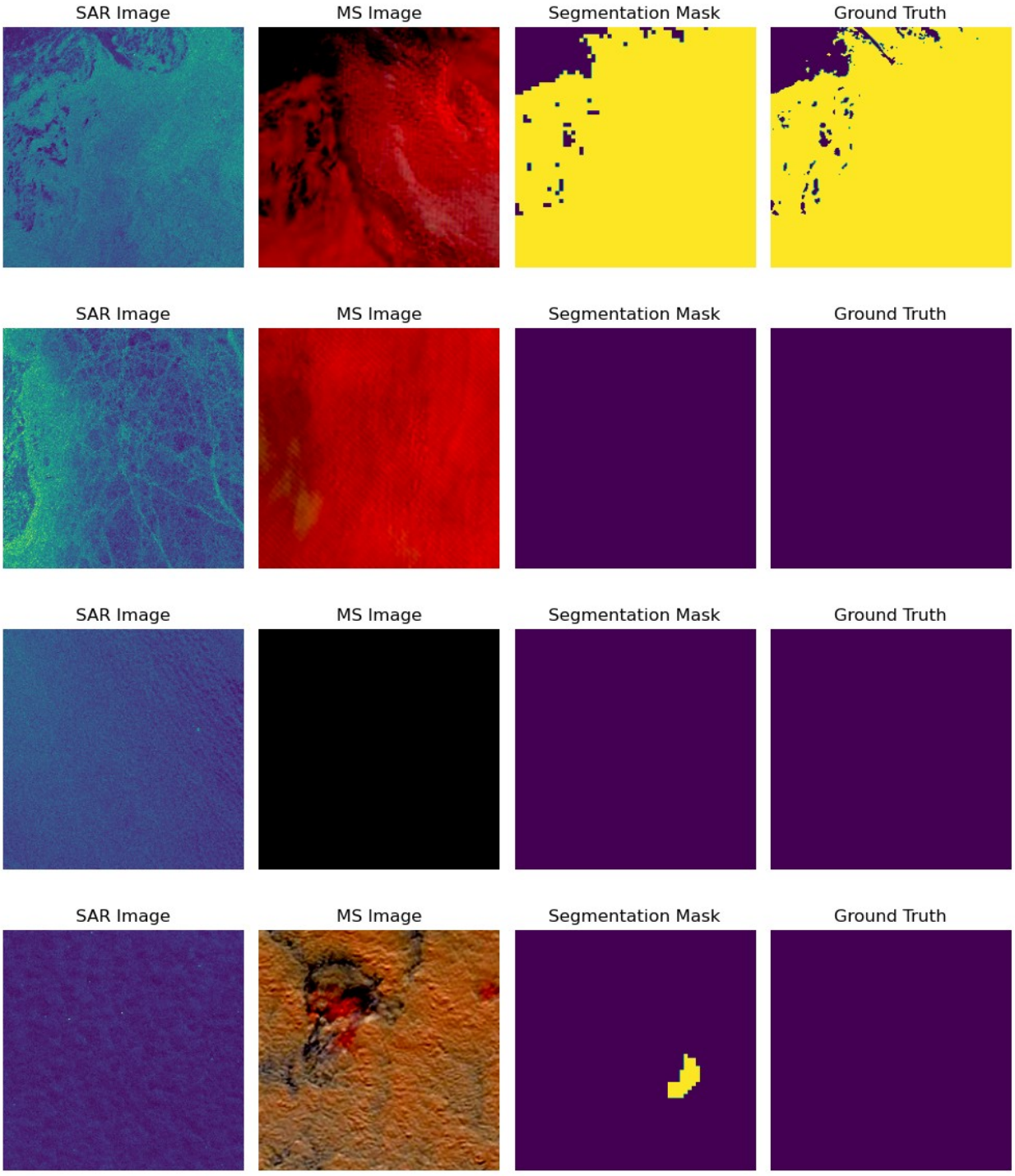
```
preds = model.predict(val_generator,steps=1)

(X_sar_test, X_ms_test), y_test = next(iter(val_generator))

for i in range(preds.shape[0]):
    plt.figure(figsize=(10, 5))
    plt.subplot(141)
    plt.imshow(X_sar_test[i,:,:,:])
    plt.title('SAR Image')
    plt.axis('off')
    plt.subplot(142)
    plt.imshow(X_ms_test[i,:,:,:])
    plt.title('MS Image')
    plt.axis('off')
    plt.subplot(143)
    plt.imshow(preds[i,:,:,0]>threshold)
    plt.title('Segmentation Mask')
```

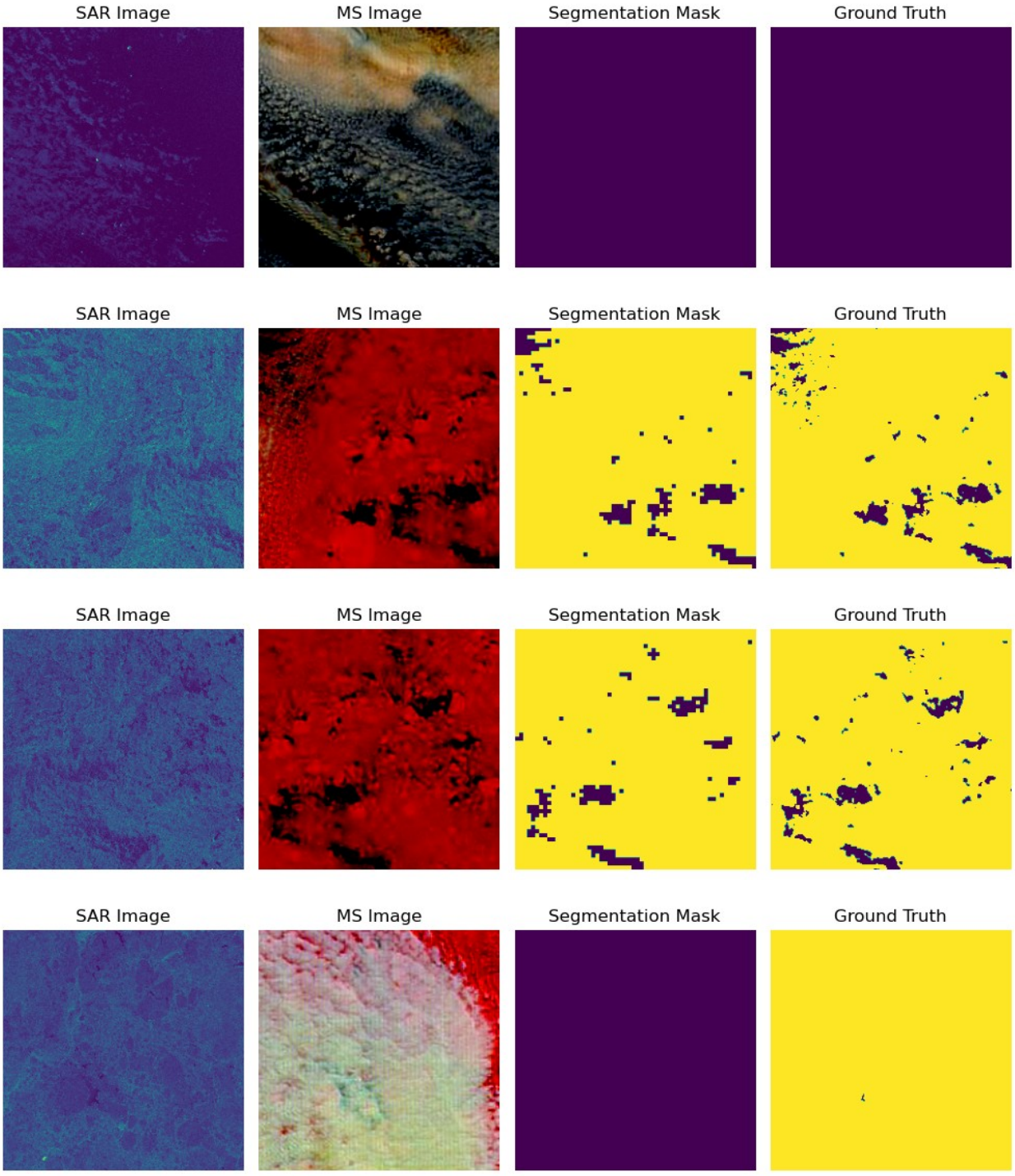
```
    plt.axis('off')
    plt.subplot(144)
    plt.imshow(y_test[i,:,:,0])
    plt.title('Ground Truth')
    plt.axis('off')
    plt.tight_layout()
    plt.show()
```

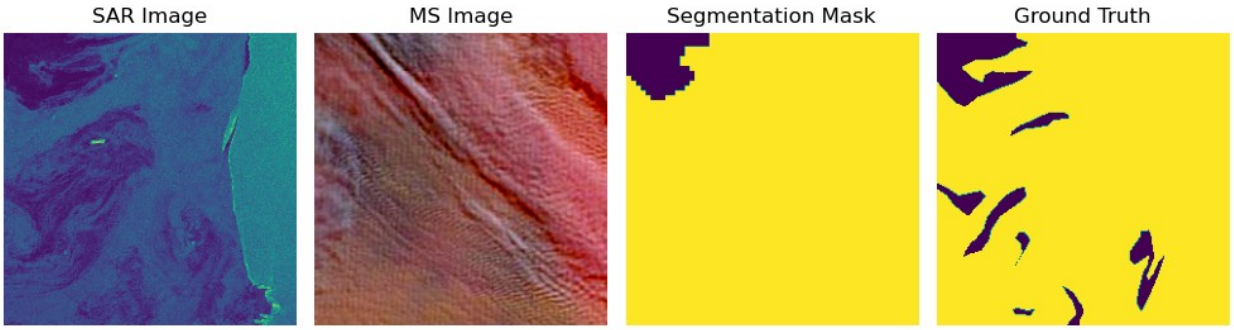
```
1/1 [==============================] - 0s 387ms/step
```




SAR Image
MS Image
Segmentation Mask
Ground Truth
SAR Image
MS Image
Segmentation Mask
Ground Truth
SAR Image
MS Image
Segmentation Mask
Ground Truth
SAR Image
MS Image
Segmentation Mask
Ground Truth


SAR Image
MS Image
Segmentation Mask
Ground Truth
SAR Image
MS Image
Segmentation Mask
Ground Truth
SAR Image
MS Image
Segmentation Mask
Ground Truth
SAR Image
MS Image
Segmentation Mask
Ground Truth


SAR Image
MS Image
Segmentation Mask
Ground Truth
SAR Image
MS Image
Segmentation Mask
Ground Truth
SAR Image
MS Image
Segmentation Mask
Ground Truth
SAR Image
MS Image
Segmentation Mask
Ground Truth




```
import pandas as pd

#ref:https://www.kaggle.com/paulorzp/run-length-encode-and-decode.
def rle_encode(mask):
    '''
    mask: numpy array binary mask
    1 - mask
    0 - background
    Returns encoded run length
    '''
    pixels = mask.flatten()
    pixels = np.concatenate([[0], pixels, [0]])
    runs = np.where(pixels[1:] != pixels[:-1])[0] + 1
    runs[1::2] -= runs[::2]
    return ' '.join(str(x) for x in runs)

# Predict on test data
predictions = model.predict(test_generator)

# Generate submission DataFrame
submission_df = pd.DataFrame(columns=['ImageId', 'EncodedPixels'])

for i, patch_path in enumerate(test_patch_paths):
    image_id = os.path.basename(patch_path)
    mask = predictions[i, :, :, 0] > threshold
    encoded_pixels = rle_encode(mask)
    submission_df.loc[i] = [image_id, encoded_pixels]

# Save submission DataFrame to CSV file
submission_df.to_csv('submission.csv', index=False)
```

```
22/22 [==============================] - 17s 784ms/step
```