```
from tensorflow import keras
from tensorflow.keras import layers
import numpy as np
from tensorflow.keras.preprocessing.image import load_img
import os
import random


!unzip "/content/drive/MyDrive/Crack/crack_segmentation_dataset/crack_segmentation_dataset


from google.colab import drive
drive.mount('/content/drive')
```

```
Mounted at /content/drive
```

```
input_dir = "/content/crack_segmentation_dataset/train/images/"
target_dir = "/content/crack_segmentation_dataset/train/masks/"
img_size = (448,448)
num_classes = 2
batch_size = 32

input_img_paths = sorted(
    [
        os.path.join(input_dir, fname)
        for fname in os.listdir(input_dir)
        if fname.endswith(".jpg")
    ]
)
target_img_paths = sorted(
    [
        os.path.join(target_dir, fname)
        for fname in os.listdir(target_dir)
        if fname.endswith(".jpg")
    ]
)

print("Number of samples:", len(input_img_paths))

for input_path, target_path in zip(input_img_paths[:10], target_img_paths[:10]):
    print(input_path, "|", target_path)
```

```
Number of samples: 9603
/content/crack_segmentation_dataset/train/images/CFD_002.jpg | /content/crack_segment
/content/crack_segmentation_dataset/train/images/CFD_003.jpg | /content/crack_segment
/content/crack_segmentation_dataset/train/images/CFD_004.jpg | /content/crack_segment
/content/crack_segmentation_dataset/train/images/CFD_005.jpg | /content/crack_segment
/content/crack_segmentation_dataset/train/images/CFD_006.jpg | /content/crack_segment
/content/crack_segmentation_dataset/train/images/CFD_008.jpg | /content/crack_segment
/content/crack_segmentation_dataset/train/images/CFD_009.jpg | /content/crack_segment
/content/crack_segmentation_dataset/train/images/CFD_010.jpg | /content/crack_segment
/content/crack_segmentation_dataset/train/images/CFD_012.jpg | /content/crack_segment
/content/crack_segmentation_dataset/train/images/CFD_015.jpg | /content/crack_segment
```

```
from IPython.display import Image, display
from tensorflow.keras.preprocessing.image import load_img
import PIL
from PIL import ImageOps
import cv2
# Display input image #7
temp = 20
display(Image(filename=input_img_paths[temp]))
img = cv2.imread(input_img_paths[temp])
print(np.max(img), np.min(img))
# Display auto-contrast version of corresponding target (per-pixel categories)
img = cv2.imread(target_img_paths[temp])
img[img>0] = 1
print(img.shape)

print(np.max(img), np.min(img))
kernel = np.ones((5,5), np.uint8)
img = cv2.dilate(img, kernel, iterations=5)
img = PIL.ImageOps.autocontrast(keras.preprocessing.image.array_to_img(img))
# img = PIL.ImageOps.autocontrast(Image(img))
# img[img==255] = 1
# print(load_img(target_img_paths[100]))
display(img)
```

```
class CracksAnn(keras.utils.Sequence):
    """Helper to iterate over the data (as Numpy arrays)."""

    def __init__(self, batch_size, img_size, input_img_paths, target_img_paths):
        self.batch_size = batch_size
        self.img_size = img_size
        self.input_img_paths = input_img_paths
        self.target_img_paths = target_img_paths

    def __len__(self):
        return len(self.target_img_paths) // self.batch_size

    def __getitem__(self, idx):
        """Returns tuple (input, target) correspond to batch #idx."""
        i = idx * self.batch_size
        batch_input_img_paths = self.input_img_paths[i : i + self.batch_size]
        batch_target_img_paths = self.target_img_paths[i : i + self.batch_size]
        x = np.zeros((self.batch_size,) + self.img_size + (3,), dtype="float32")
        for j, path in enumerate(batch_input_img_paths):
            img = load_img(path, target_size=self.img_size)
            x[j] = img
        y = np.zeros((self.batch_size,) + self.img_size + (1,), dtype="uint8")
        # print('yshape:',y.shape)
        for j, path in enumerate(batch_target_img_paths):
            img = np.array(load_img(path, target_size=self.img_size, color_mode="grayscale
            # img = np.interp(img, (np.min(img), np.max(img)), (1, 3)).astype(int)
            img[img>0] = 1
            kernel = np.ones((5,5), np.uint8)
            img = cv2.dilate(img, kernel, iterations=5)
            y[j] = np.expand_dims(img, 2)
            # Ground truth labels are 1, 2, 3. Subtract one to make them 0, 1, 2:
            # y[j] -= 1
```

```
        # print('yshape:',y.shape)
        return x, y


    def get_model(img_size, num_classes):
        inputs = keras.Input(shape=img_size + (3,))
        # x = layers.experimental.preprocessing.Rescaling(1.0 / 255)(inputs)
        ### [First half of the network: downsampling inputs] ###

        # Entry block
        x = layers.Conv2D(32, 3, strides=2, padding="same")(inputs)
        x = layers.BatchNormalization()(x)
        x = layers.Activation("relu")(x)

        previous_block_activation = x  # Set aside residual

        # Blocks 1, 2, 3 are identical apart from the feature depth.
        for filters in [64, 128, 256]:
            x = layers.Activation("relu")(x)
            x = layers.SeparableConv2D(filters, 3, padding="same")(x)
            x = layers.BatchNormalization()(x)

            x = layers.Activation("relu")(x)
            x = layers.SeparableConv2D(filters, 3, padding="same")(x)
            x = layers.BatchNormalization()(x)

            x = layers.MaxPooling2D(3, strides=2, padding="same")(x)

            # Project residual
            residual = layers.Conv2D(filters, 1, strides=2, padding="same")(
                previous_block_activation
            )
            x = layers.add([x, residual])  # Add back residual
            previous_block_activation = x  # Set aside next residual

        ### [Second half of the network: upsampling inputs] ###

        for filters in [256, 128, 64, 32]:
            x = layers.Activation("relu")(x)
            x = layers.Conv2DTranspose(filters, 3, padding="same")(x)
            x = layers.BatchNormalization()(x)

            x = layers.Activation("relu")(x)
            x = layers.Conv2DTranspose(filters, 3, padding="same")(x)
            x = layers.BatchNormalization()(x)

            x = layers.UpSampling2D(2)(x)

            # Project residual
            residual = layers.UpSampling2D(2)(previous_block_activation)
            residual = layers.Conv2D(filters, 1, padding="same")(residual)
            x = layers.add([x, residual])  # Add back residual
            previous_block_activation = x  # Set aside next residual

        # Add a per-pixel classification layer
        outputs = layers.Conv2D(num_classes, 3, activation="softmax", padding="same")(x)
```

```
    outputs = layers.Conv2D(num_classes, 3, activation="softmax", padding="same")(x)

    # Define the model
    model = keras.Model(inputs, outputs)
    return model


# Free up RAM in case the model definition cells were run multiple times
keras.backend.clear_session()

# Build model
model = get_model(img_size, num_classes)
model.summary()
```

```
Model: "functional_1"
__________________________________________________________________________________________________
Layer (type)                    Output Shape         Param #     Connected to
==================================================================================================
input_1 (InputLayer)            [(None, 448, 448, 3) 0
__________________________________________________________________________________________________
conv2d (Conv2D)                 (None, 224, 224, 32) 896         input_1[0][0]
__________________________________________________________________________________________________
batch_normalization (BatchNorma (None, 224, 224, 32) 128         conv2d[0][0]
__________________________________________________________________________________________________
activation (Activation)         (None, 224, 224, 32) 0           batch_normalizat
__________________________________________________________________________________________________
activation_1 (Activation)       (None, 224, 224, 32) 0           activation[0][0]
__________________________________________________________________________________________________
separable_conv2d (SeparableConv (None, 224, 224, 64) 2400        activation_1[0][
__________________________________________________________________________________________________
batch_normalization_1 (BatchNor (None, 224, 224, 64) 256         separable_conv2d
__________________________________________________________________________________________________
activation_2 (Activation)       (None, 224, 224, 64) 0           batch_normalizat
__________________________________________________________________________________________________
separable_conv2d_1 (SeparableCo (None, 224, 224, 64) 4736        activation_2[0][
__________________________________________________________________________________________________
batch_normalization_2 (BatchNor (None, 224, 224, 64) 256         separable_conv2d
__________________________________________________________________________________________________
max_pooling2d (MaxPooling2D)    (None, 112, 112, 64) 0           batch_normalizat
__________________________________________________________________________________________________
conv2d_1 (Conv2D)               (None, 112, 112, 64) 2112        activation[0][0]
__________________________________________________________________________________________________
add (Add)                       (None, 112, 112, 64) 0           max_pooling2d[0]
                                                                 conv2d_1[0][0]
__________________________________________________________________________________________________
activation_3 (Activation)       (None, 112, 112, 64) 0           add[0][0]
__________________________________________________________________________________________________
separable_conv2d_2 (SeparableCo (None, 112, 112, 128 8896        activation_3[0][
__________________________________________________________________________________________________
batch_normalization_3 (BatchNor (None, 112, 112, 128 512         separable_conv2d
__________________________________________________________________________________________________
activation_4 (Activation)       (None, 112, 112, 128 0           batch_normalizat
__________________________________________________________________________________________________
separable_conv2d_3 (SeparableCo (None, 112, 112, 128 17664       activation_4[0][
__________________________________________________________________________________________________
batch_normalization_4 (BatchNor (None, 112, 112, 128 512         separable_conv2d
__________________________________________________________________________________________________
max_pooling2d_1 (MaxPooling2D)  (None, 56, 56, 128)  0           batch_normalizat
__________________________________________________________________________________________________
conv2d_2 (Conv2D)               (None, 56, 56, 128)  8320        add[0][0]
```

```
add_1 (Add)                     (None, 56, 56, 128)  0           max_pooling2d_1[
                                                                 conv2d_2[0][0]
__________________________________________________________________________________
activation_5 (Activation)       (None, 56, 56, 128)  0           add_1[0][0]
__________________________________________________________________________________
separable_conv2d_4 (SeparableCo (None, 56, 56, 256)  34176       activation_5[0][
__________________________________________________________________________________
batch_normalization_5 (BatchNor (None, 56, 56, 256)  1024        separable_conv2d
__________________________________________________________________________________
activation_6 (Activation)       (None, 56, 56, 256)  0           batch_normalizat
```

```
val_samples = 500
random.Random(1337).shuffle(input_img_paths)
random.Random(1337).shuffle(target_img_paths)
train_input_img_paths = input_img_paths[:-val_samples]
train_target_img_paths = target_img_paths[:-val_samples]
val_input_img_paths = input_img_paths[-val_samples:]
val_target_img_paths = target_img_paths[-val_samples:]

# Instantiate data Sequences for each split
train_gen = CracksAnn(
    batch_size, img_size, train_input_img_paths, train_target_img_paths
)
val_gen = CracksAnn(batch_size, img_size, val_input_img_paths, val_target_img_paths)


# Configure the model for training.
# We use the "sparse" version of categorical_crossentropy
# because our target data is integers.
model.compile(optimizer=keras.optimizers.Adam(2e-5), loss="sparse_categorical_crossentropy

# callbacks = [
#     keras.callbacks.ModelCheckpoint("/content/drive/MyDrive/Colab/Project/Crack segement
# ]

# Train the model, doing validation at the end of each epoch.
epochs = 10
model.fit(train_gen, epochs=epochs, validation_data=val_gen)
```

```
Epoch 1/10
  2/284 [..............................] - ETA: 6:54 - loss: 0.1881 - accuracy: 0.904
284/284 [==============================] - 491s 2s/step - loss: 0.1741 - accuracy: 0
Epoch 2/10
284/284 [==============================] - 488s 2s/step - loss: 0.1690 - accuracy: 0
Epoch 3/10
284/284 [==============================] - 488s 2s/step - loss: 0.1643 - accuracy: 0
Epoch 4/10
284/284 [==============================] - 490s 2s/step - loss: 0.1597 - accuracy: 0
Epoch 5/10
284/284 [==============================] - 490s 2s/step - loss: 0.1561 - accuracy: 0
Epoch 6/10
284/284 [==============================] - 489s 2s/step - loss: 0.1522 - accuracy: 0
Epoch 7/10
284/284 [==============================] - 489s 2s/step - loss: 0.1489 - accuracy: 0
Epoch 8/10
```

```
284/284 [==============================] - 489s 2s/step - loss: 0.1461 - accuracy: 0
Epoch 9/10
284/284 [==============================] - 488s 2s/step - loss: 0.1430 - accuracy: 0
Epoch 10/10
284/284 [==============================] - 489s 2s/step - loss: 0.1411 - accuracy: 0
<tensorflow.python.keras.callbacks.History at 0x7fda902e9898>
```

```
model.save("/content/drive/MyDrive/trained_model_newData_30epochs.h5")
```

```
test_img = load_img("/content/drive/MyDrive/Colab/train/cracked/11.jpg")
pred = model.predict(test_img)
```

Double-click (or enter) to edit

```
val_gen_new = CracksAnn(batch_size, img_size, val_input_img_paths, val_target_img_paths)
val_preds = model.predict(val_gen)
print("val : ", val_preds.shape[0])
```

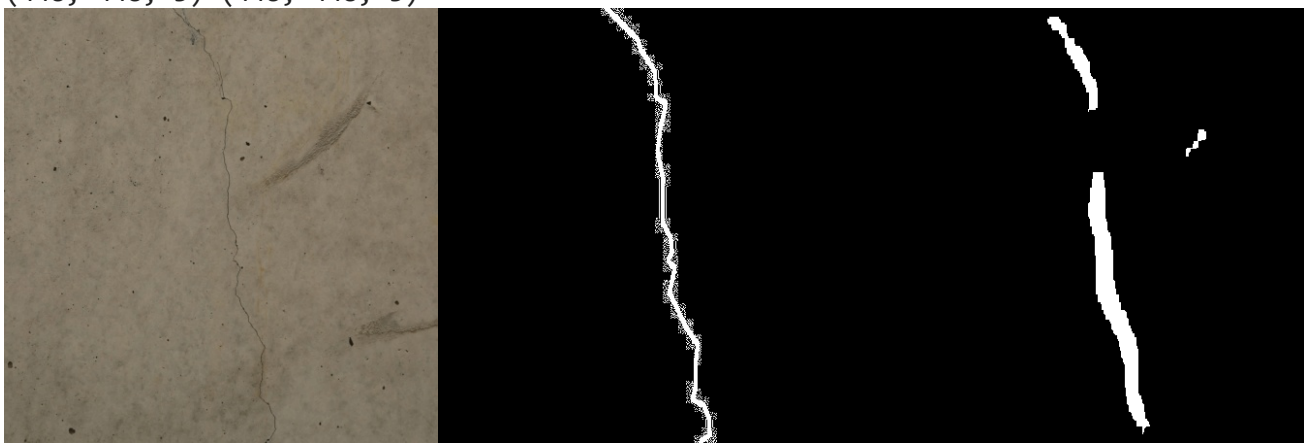
```
def display_mask(i):
    """Quick utility to display a model's prediction."""
    print("val : ", val_preds[i].shape)
    # print(val_preds[i])
    mask = np.argmax(val_preds[i], axis=-1)
    mask = np.expand_dims(mask, axis=-1)
    print("mask : ", mask.shape)
    img = PIL.ImageOps.autocontrast(keras.preprocessing.image.array_to_img(mask))
    display(img)
    # img = np.array(img)
    # print(img.shape)
```

```
val :  480
```

```
i = 15
og_img = cv2.imread(val_input_img_paths[i])
# display(Image(filename=val_input_img_paths[i]))
exp_mask = cv2.imread(val_target_img_paths[i])
mask = np.argmax(val_preds[i], axis=-1)
mask[mask==1] = 255
mask = np.array(mask, dtype = np.uint8)

kernel = np.ones((5,5), np.uint8)
mask = cv2.erode(mask, kernel, iterations = 4)

print(exp_mask.shape, mask.shape)
mask = np.stack((mask,)*3, axis=-1)
print(exp_mask.shape, mask.shape)

# mask = np.expand_dims(mask, axis=-1)
# print(mask.shape, exp_mask.shape)
# print(exp_mask)
```

```
# print(exp_mask)
view_mode = np.concatenate((og_img, exp_mask, mask), axis = 1)
img = PIL.ImageOps.autocontrast(keras.preprocessing.image.array_to_img(view_mode))
display(img)
```

```
(448, 448, 3) (448, 448)
(448, 448, 3) (448, 448, 3)
```



```
for i in range(val_preds.shape[0]):
  # display(Image(filename=val_input_img_paths[i]))
  og_img = cv2.imread(val_input_img_paths[i])
  exp_mask = cv2.imread(val_target_img_paths[i])

  mask = np.argmax(val_preds[i], axis=-1)
  mask[mask==1] = 255
  mask = np.array(mask, dtype = np.uint8)
  kernel = np.ones((5,5), np.uint8)
  mask = cv2.erode(mask, kernel, iterations = 4)
  mask = np.stack((mask,)*3, axis=-1)

  view_mode = np.concatenate((og_img, exp_mask, mask), axis = 1)
  img = PIL.ImageOps.autocontrast(keras.preprocessing.image.array_to_img(view_mode))
  # cv2.imwrite("/content/drive/MyDrive/Crack/crack_segmentation_dataset/Output_validation
```

```
cfd_input_dir = "/content/drive/MyDrive/Crack/cfd_image.zip (Unzipped Files)/cfd_image/"
cfd_target_dir = "/content/drive/MyDrive/Crack/cfd_image.zip (Unzipped Files)/seg_gt/"

cfd_input_img_paths = sorted(
    [
        os.path.join(cfd_input_dir, fname)
        for fname in os.listdir(cfd_input_dir)
        if fname.endswith(".jpg")
    ]
)
cfd_target_img_paths = sorted(
    [
        os.path.join(cfd_target_dir, fname)
        for fname in os.listdir(cfd_target_dir)
        if fname.endswith(".png")
```

```
        if fname.endswith(".png")
    ]
)

print("Number of samples:", len(cfd_input_img_paths))

for input_path, target_path in zip(cfd_input_img_paths[:10], cfd_target_img_paths[:10]):
    print(input_path, "|", target_path)
```

```
Number of samples: 118
/content/drive/MyDrive/Crack/cfd_image.zip (Unzipped Files)/cfd_image/001.jpg | /cont
/content/drive/MyDrive/Crack/cfd_image.zip (Unzipped Files)/cfd_image/002.jpg | /cont
/content/drive/MyDrive/Crack/cfd_image.zip (Unzipped Files)/cfd_image/003.jpg | /cont
/content/drive/MyDrive/Crack/cfd_image.zip (Unzipped Files)/cfd_image/004.jpg | /cont
/content/drive/MyDrive/Crack/cfd_image.zip (Unzipped Files)/cfd_image/005.jpg | /cont
/content/drive/MyDrive/Crack/cfd_image.zip (Unzipped Files)/cfd_image/006.jpg | /cont
/content/drive/MyDrive/Crack/cfd_image.zip (Unzipped Files)/cfd_image/007.jpg | /cont
/content/drive/MyDrive/Crack/cfd_image.zip (Unzipped Files)/cfd_image/008.jpg | /cont
/content/drive/MyDrive/Crack/cfd_image.zip (Unzipped Files)/cfd_image/009.jpg | /cont
/content/drive/MyDrive/Crack/cfd_image.zip (Unzipped Files)/cfd_image/010.jpg | /cont
```

```
kernel = np.ones((5,5), np.uint8)
for j in range(len(cfd_input_img_paths)):
  cfd_img = np.expand_dims(cv2.imread(cfd_input_img_paths[j]), axis = 0)
  cfd_img_pred = model.predict(cfd_img)[0]
  cfd_img_pred = np.array(np.argmax(cfd_img_pred, axis=-1), dtype = np.uint8)
  cfd_img_pred = cv2.erode(cfd_img_pred, kernel, iterations = 4)
  cfd_img_pred = np.expand_dims(cfd_img_pred, axis = -1)
  cfd_img_pred[cfd_img_pred==1] = 255
  name = j+1
  cv2.imwrite("/content/drive/MyDrive/Crack/cfd_image.zip (Unzipped Files)/cfd_image_predi
print(cfd_img_pred.shape)
```

```
(320, 480, 1)
```

```
display(Image(filename=cfd_input_img_paths[j]))
pred = PIL.ImageOps.autocontrast(keras.preprocessing.image.array_to_img(cfd_img_pred))
display(pred)
```