```
from keras.models import Model
from keras.preprocessing.image import ImageDataGenerator
from keras.layers import Input, Conv2D, Dropout, MaxPooling2D, Conv2DTranspose, concatenate
from keras.optimizers import Adam
from keras.callbacks import ModelCheckpoint
from keras.utils import to_categorical, Sequence
from keras import backend as K
from skimage.io import imread, imsave
from skimage.external.tifffile import TiffWriter
from scipy.ndimage import interpolation
from copy import deepcopy
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import os
import glob
import time
import sys
import random
import cv2
import tensorflow as tf
from tensorflow import keras


from google.colab import drive
drive.mount('/content/gdrive')
import os
os.chdir('/content/gdrive/My Drive/data')
img_train_path = ('/content/gdrive/My Drive/data/2Dimages/train_img')
lesion_train_path = ('/content/gdrive/My Drive/data/2Dimages/train_lesion')
img_valid_path = ('/content/gdrive/My Drive/data/2Dimages/valid_img')
lesion_valid_path = ('/content/gdrive/My Drive/data/2Dimages/valid_lesion')
img_test_path = ('/content/gdrive/My Drive/data/2Dimages/test_img')
lesion_test_path = ('/content/gdrive/My Drive/data/2Dimages/test_lesion')
```

```
Drive already mounted at /content/gdrive; to attempt to forcibly remount, call drive.mount("
```

```
seed = 2021
img_size = (128, 64)
data_args = dict(
        rescale=1./255,
        rotation_range=10.,
        width_shift_range=0.1,
        height_shift_range=0.1,
        zoom_range=0.1,
        shear_range=0.1,
        horizontal_flip=True,
        fill_mode='constant',
        cval=0)

img_train_final = ImageDataGenerator(**data_args)
lesion_train_final = ImageDataGenerator(**data_args)
```

```
img_valid_final = ImageDataGenerator(rescale=1./255)
lesion_valid_final = ImageDataGenerator(rescale=1./255)
img_test_final = ImageDataGenerator(rescale=1./255)
lesion_test_final = ImageDataGenerator(rescale=1./255)

flow_args = dict(target_size=img_size,
                                color_mode = 'grayscale',
                                batch_size = 32,
                                class_mode = None,
                                seed = seed)

img_train_generator = img_train_final.flow_from_directory(img_train_path, **flow_args)
lesion_train_generator = lesion_train_final.flow_from_directory(lesion_train_path, **flow_args)
train_generator = zip(img_train_generator, lesion_train_generator)
#########################################################################################################
img_valid_generator = img_valid_final.flow_from_directory(img_valid_path, **flow_args)
lesion_valid_generator = lesion_valid_final.flow_from_directory(lesion_valid_path, **flow_args)
valid_generator = zip(img_valid_generator, lesion_valid_generator)
#########################################################################################################
img_test_generator = img_test_final.flow_from_directory(img_test_path, **flow_args)
lesion_test_generator = lesion_test_final.flow_from_directory(lesion_test_path, **flow_args)
test_generator = zip(img_test_generator, lesion_test_generator)



x = img_train_generator.__getitem__(0)
print(x.shape)
y = lesion_train_generator.__getitem__(0)
print(y.shape)
x1 = img_valid_generator.__getitem__(0)
print(x1.shape)
y1 = lesion_valid_generator.__getitem__(0)
print(y1.shape)
x2 = img_test_generator.__getitem__(0)
print(x2.shape)
y2 = lesion_test_generator.__getitem__(0)
print(y2.shape)
```

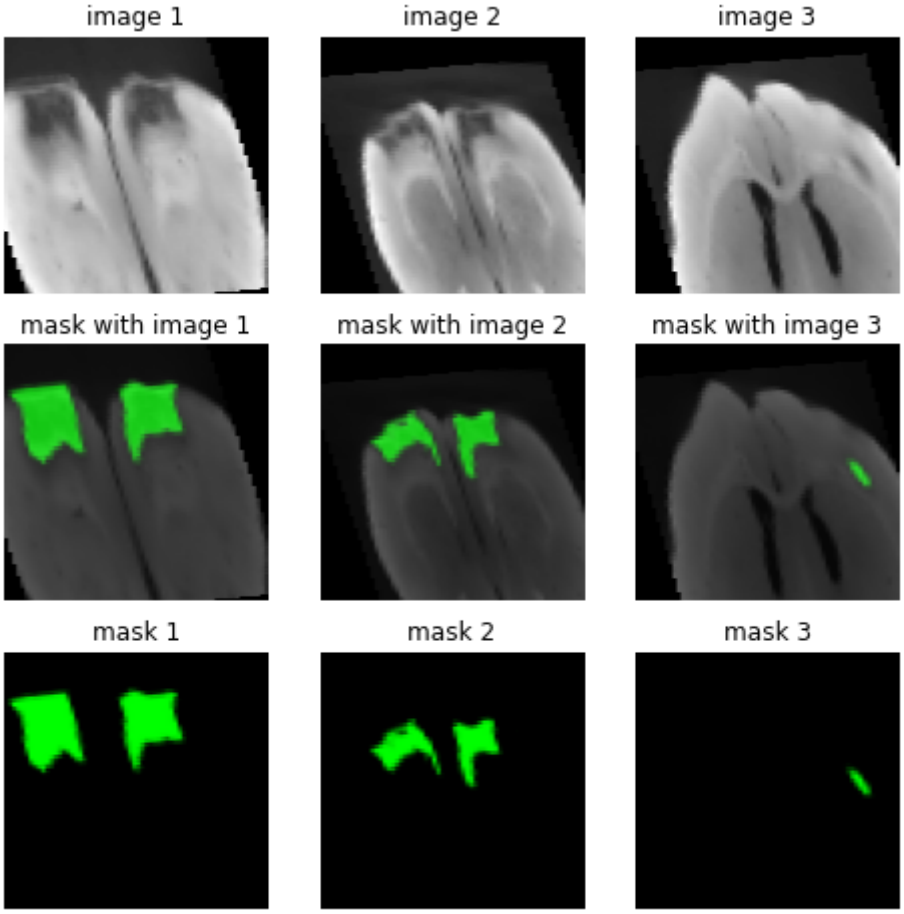
```
Found 35 images belonging to 1 classes.
Found 35 images belonging to 1 classes.
Found 78 images belonging to 1 classes.
Found 78 images belonging to 1 classes.
Found 79 images belonging to 1 classes.
Found 79 images belonging to 1 classes.
(32, 128, 64, 1)
(32, 128, 64, 1)
(32, 128, 64, 1)
(32, 128, 64, 1)
(32, 128, 64, 1)
(32, 128, 64, 1)
```

```
smooth = 1.

def dice(y_true, y_pred): # for numpy arrays
        y_true_f = y_true.reshape(-1)
        y_pred_f = y_pred.reshape(-1)
        intersection = np.sum(y_true_f*y_pred_f)
```

```
        if np.sum(y_true_f + y_pred_f)==0:
            return 1.0
        return (2. * intersection) / (np.sum(y_true_f) + np.sum(y_pred_f))

def dice_coef(y_true, y_pred):
        y_true_f = K.flatten(y_true)
        y_pred_f = K.flatten(y_pred)
        intersection = K.sum(y_true_f * y_pred_f)
        if K.sum(y_true_f + y_pred_f)==0:
            return 1.0
        return (2. * intersection + smooth) / (K.sum(y_true_f) + K.sum(y_pred_f) + smoot

def dice_coef_loss(y_true, y_pred):
        return 1-dice_coef(y_true, y_pred)


def check_masks(data_batch,labels_batch,predictions=None):
    if predictions is None:
        predictions = np.zeros_like(labels_batch)
    plt.figure(figsize=(8,8))

    for i, (img, mask, pred) in enumerate(zip(data_batch, labels_batch, predictions)):
            # image only
            plt.subplot(3,3,i+1)
            h = plt.imshow(np.squeeze(img), aspect='auto')
            h.set_cmap('gray')
            plt.axis('off')
            plt.title('image %d' % (i+1))

            # overlay mask + image
            plt.subplot(3,3,i+4)
            merged = 0.7*np.tile(img, (1,1,3))
            if pred.max()==0:
                merged[:,:,1] += 0.7*np.squeeze(mask)
            else:
                merged[:,:,0] += 0.7*np.squeeze(pred)
            merged[merged>1] = 1

            h = plt.imshow(merged, aspect='auto')
            plt.axis('off')
            if pred.max()==0:
                plt.title('mask with image %d' % (i+1))
            else:
                plt.title('Predictions')


            # overlay mask + prediction
            plt.subplot(3,3,i+7)
            masks = np.concatenate([pred, np.zeros(mask.shape[:2]+(2,))], axis=2)
            masks[:,:,1] += np.squeeze(mask)
            plt.imshow(masks, aspect='auto')
            plt.axis('off')
            if pred.max()>0:
                plt.title('Dice: %1.3f' % dice_coef(mask, pred))
            else:
                plt.title('mask %d' % (i+1))
```

```
                plt.title('mask %d' % (i+1))

            if i==2:
                break


# check dataset
for data_batch, labels_batch in train_generator:
    print('data batch shape:', data_batch.shape)
    print('labels batch shape:', labels_batch.shape)
    break

check_masks(data_batch, labels_batch)
```

```
data batch shape: (32, 128, 64, 1)
labels batch shape: (32, 128, 64, 1)
```




```
one_weight = 0.95 # class weights
zero_weight = 0.05

def weighted_binary_crossentropy(y_true, y_pred):

    # Original binary crossentropy (see losses.py):
    # K.mean(K.binary_crossentropy(y_true, y_pred), axis=-1)

    # Calculate the binary crossentropy
    b_ce = K.binary_crossentropy(y_true, y_pred)

    # Apply the weights
    weight_vector = y_true * one_weight + (1. - y_true) * zero_weight
```

```
        weighted_b_ce = weight_vector * b_ce

        # Return the mean error
        return K.mean(weighted_b_ce)


def batch_norm(x, act=True):
        x = keras.layers.BatchNormalization()(x)
        if act == True:
                x = keras.layers.Activation("relu")(x)
        return x

def conv_block(x, filters, kernel_size=(3, 3), padding="same", strides=1):
        conv = batch_norm(x)
        conv = keras.layers.Conv2D(filters, kernel_size, padding=padding, strides=strides)(con
        return conv

def Mainbody(x, filters, kernel_size=(3, 3), padding="same", strides=1):
        conv = keras.layers.Conv2D(filters, kernel_size, padding=padding, strides=strides)(x)
        conv = conv_block(conv, filters, kernel_size=kernel_size, padding=padding, strides=st

        shortcut = keras.layers.Conv2D(filters, kernel_size=(1, 1), padding=padding, strides=
        shortcut = batch_norm(shortcut, act=False)

        output = keras.layers.Add()([conv, shortcut])
        return output

def residual_block(x, filters, kernel_size=(3, 3), padding="same", strides=1):
        res = conv_block(x, filters, kernel_size=(3, 3), padding=padding, strides=strides)
        res = conv_block(res, filters, kernel_size=(3, 3), padding=padding, strides=1)

        shortcut = keras.layers.Conv2D(filters, kernel_size=(1, 1), padding=padding, strides=
        shortcut = bn_act(shortcut, act=False)

        output = keras.layers.Add()([shortcut, res])
        return output

def concat_blocks(x, xskip):
        u = keras.layers.UpSampling2D((2, 2))(x)
        c = keras.layers.Concatenate()([u, xskip])
        return c


def ResUNet(loss_fn=dice_coef_loss, lr=1e-3, act='relu', init='he_normal', pad='same', dropou
        inputs = keras.layers.Input((128, 64, 1))

        ## Encoder
        c0 = inputs
        c1 = Mainbody(c0, 16)
        c2 = residual_block(c1, 32, strides=2)
        c3 = residual_block(c2, 64, strides=2)
        c4 = residual_block(c3, 128, strides=2)
        c5 = residual_block(c4, 256, strides=2)

        ## Bridge
        b0 = conv_block(c5, 256, strides=1)
```

```
    b0 = conv_block(c5, 256, strides=1)
    b1 = conv_block(b0, 256, strides=1)

    ## Decoder
    u1 = concat_blocks(b1, c4)
    d1 = residual_block(u1, 256)

    u2 = concat_blocks(d1, c3)
    d2 = residual_block(u2, 128)

    u3 = concat_blocks(d2, c2)
    d3 = residual_block(u3, 64)

    u4 = concat_blocks(d3, c1)
    d4 = residual_block(u4, 32)

    outputs = keras.layers.Conv2D(1, (1, 1), padding="same", activation="sigmoid")(d4)
    model = keras.models.Model(inputs, outputs)
    return model


model = ResUNet()
adam = keras.optimizers.Adam()
model.compile(optimizer=adam, loss=dice_coef_loss, metrics=[dice_coef])
model.summary()
```

add_24 (Add)	(None, 32, 16, 128)	0	batch_normalization_77[0] conv2d_81[0][0]
up_sampling2d_10 (UpSampling2D)	(None, 64, 32, 128)	0	add_24[0][0]
concatenate_10 (Concatenate)	(None, 64, 32, 160)	0	up_sampling2d_10[0][0] add_19[0][0]
batch_normalization_78 (BatchNo	(None, 64, 32, 160)	640	concatenate_10[0][0]
activation_53 (Activation)	(None, 64, 32, 160)	0	batch_normalization_78[0]
conv2d_83 (Conv2D)	(None, 64, 32, 64)	92224	activation_53[0][0]
batch_normalization_79 (BatchNo	(None, 64, 32, 64)	256	conv2d_83[0][0]
conv2d_85 (Conv2D)	(None, 64, 32, 64)	10304	concatenate_10[0][0]
activation_54 (Activation)	(None, 64, 32, 64)	0	batch_normalization_79[0]
batch_normalization_80 (BatchNo	(None, 64, 32, 64)	256	conv2d_85[0][0]
conv2d_84 (Conv2D)	(None, 64, 32, 64)	36928	activation_54[0][0]
add_25 (Add)	(None, 64, 32, 64)	0	batch_normalization_80[0] conv2d_84[0][0]
up_sampling2d_11 (UpSampling2D)	(None, 128, 64, 64)	0	add_25[0][0]
concatenate_11 (Concatenate)	(None, 128, 64, 80)	0	up_sampling2d_11[0][0] add_18[0][0]
batch_normalization_81 (BatchNo	(None, 128, 64, 80)	320	concatenate_11[0][0]

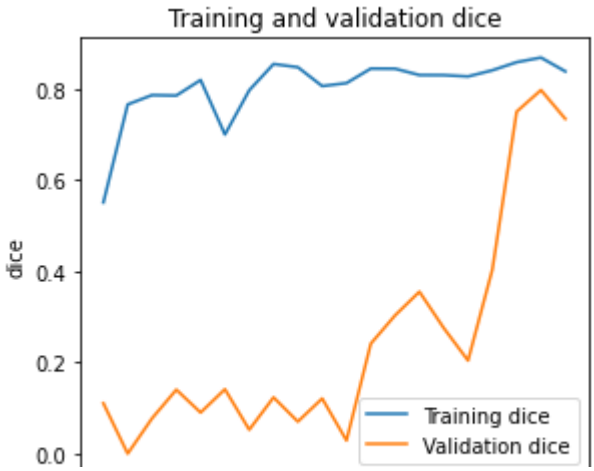
```
activation_55 (Activation)      (None, 128, 64, 80)  0           batch_normalization_81[0]
conv2d_86 (Conv2D)              (None, 128, 64, 32)  23072       activation_55[0][0]
batch_normalization_82 (BatchNo (None, 128, 64, 32)  128         conv2d_86[0][0]
conv2d_88 (Conv2D)              (None, 128, 64, 32)  2592        concatenate_11[0][0]
activation_56 (Activation)      (None, 128, 64, 32)  0           batch_normalization_82[0]
batch_normalization_83 (BatchNo (None, 128, 64, 32)  128         conv2d_88[0][0]
conv2d_87 (Conv2D)              (None, 128, 64, 32)  9248        activation_56[0][0]
add_26 (Add)                    (None, 128, 64, 32)  0           batch_normalization_83[0]
                                                                 conv2d_87[0][0]
conv2d_89 (Conv2D)              (None, 128, 64, 1)   33          add_26[0][0]
==================================================================================================
Total params: 4,722,737
Trainable params: 4,715,441
Non-trainable params: 7,296
__________________________________________________________________________________________________
```

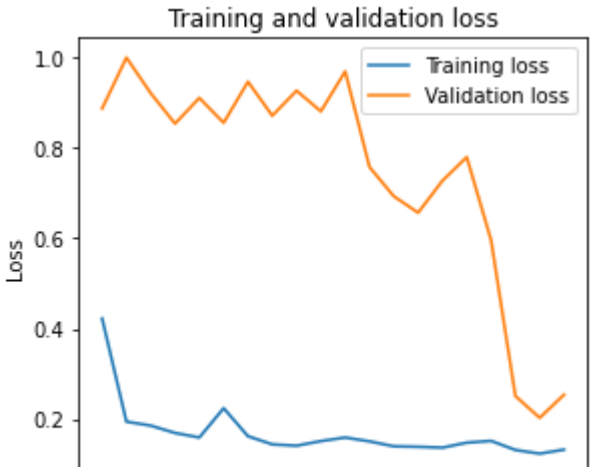
```
checkpoint = ModelCheckpoint(filepath='ResUNet.h5', monitor='val_loss', save_best_only=True)
history = model.fit_generator(
        train_generator,
        steps_per_epoch=30,
        epochs=20,
        validation_data=valid_generator,
        validation_steps=10,
        verbose=1,
        callbacks=[checkpoint])
```

```
Epoch 1/20
/usr/local/lib/python3.7/dist-packages/tensorflow/python/keras/engine/training.py:1844: User
  warnings.warn('`Model.fit_generator` is deprecated and '
30/30 [==============================] - 136s 5s/step - loss: 0.6256 - dice_coef: 0.3609 - va
Epoch 2/20
30/30 [==============================] - 132s 5s/step - loss: 0.2064 - dice_coef: 0.7652 - va
Epoch 3/20
30/30 [==============================] - 132s 5s/step - loss: 0.1877 - dice_coef: 0.7833 - va
Epoch 4/20
30/30 [==============================] - 132s 5s/step - loss: 0.1794 - dice_coef: 0.7681 - va
Epoch 5/20
30/30 [==============================] - 132s 5s/step - loss: 0.1841 - dice_coef: 0.7855 - va
Epoch 6/20
30/30 [==============================] - 132s 5s/step - loss: 0.2225 - dice_coef: 0.6815 - va
Epoch 7/20
30/30 [==============================] - 132s 5s/step - loss: 0.1553 - dice_coef: 0.8226 - va
Epoch 8/20
30/30 [==============================] - 132s 5s/step - loss: 0.1451 - dice_coef: 0.8562 - va
Epoch 9/20
30/30 [==============================] - 132s 5s/step - loss: 0.1399 - dice_coef: 0.8538 - va
```

```
Epoch 10/20
30/30 [==============================] - 132s 5s/step - loss: 0.1531 - dice_coef: 0.8134 - va
Epoch 11/20
30/30 [==============================] - 131s 4s/step - loss: 0.1413 - dice_coef: 0.8387 - va
Epoch 12/20
30/30 [==============================] - 132s 5s/step - loss: 0.1677 - dice_coef: 0.8315 - va
Epoch 13/20
30/30 [==============================] - 133s 5s/step - loss: 0.1383 - dice_coef: 0.8503 - va
Epoch 14/20
30/30 [==============================] - 132s 5s/step - loss: 0.1373 - dice_coef: 0.8447 - va
Epoch 15/20
30/30 [==============================] - 132s 5s/step - loss: 0.1367 - dice_coef: 0.8458 - va
Epoch 16/20
30/30 [==============================] - 132s 5s/step - loss: 0.1368 - dice_coef: 0.8493 - va
Epoch 17/20
30/30 [==============================] - 131s 4s/step - loss: 0.1557 - dice_coef: 0.8296 - va
Epoch 18/20
30/30 [==============================] - 132s 5s/step - loss: 0.1357 - dice_coef: 0.8474 - va
Epoch 19/20
30/30 [==============================] - 132s 5s/step - loss: 0.1279 - dice_coef: 0.8597 - va
Epoch 20/20
30/30 [==============================] - 131s 4s/step - loss: 0.1303 - dice_coef: 0.8422 - va
```

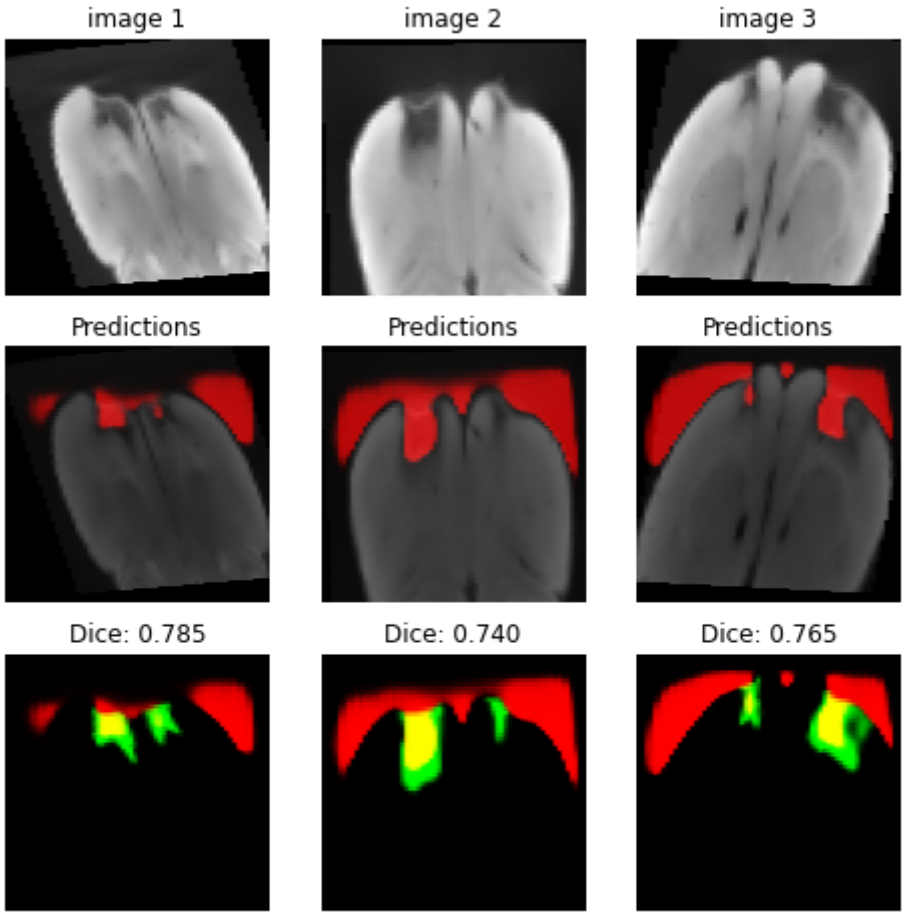
```
def plot_performance(history):
    dicec = history.history['dice_coef']
    val_dice = history.history['val_dice_coef']
    loss = history.history['loss']
    val_loss = history.history['val_loss']

    epochs = range(len(dicec))
    plt.figure(figsize=(10, 4))
    plt.subplot(1,2,1)
    plt.plot(epochs, dicec, label='Training dice')
    plt.plot(epochs, val_dice, label='Validation dice')
    plt.xlabel("Num of Epochs")
    plt.ylabel("dice")
    plt.title('Training and validation dice')
    plt.legend()

    plt.subplot(1,2,2)

    plt.plot(epochs, loss, label='Training loss')
    plt.plot(epochs, val_loss, label='Validation loss')
    plt.xlabel("Num of Epochs")
    plt.ylabel("Loss")
    plt.title('Training and validation loss')
    plt.legend()

    plt.show()


plot_performance(history)
```





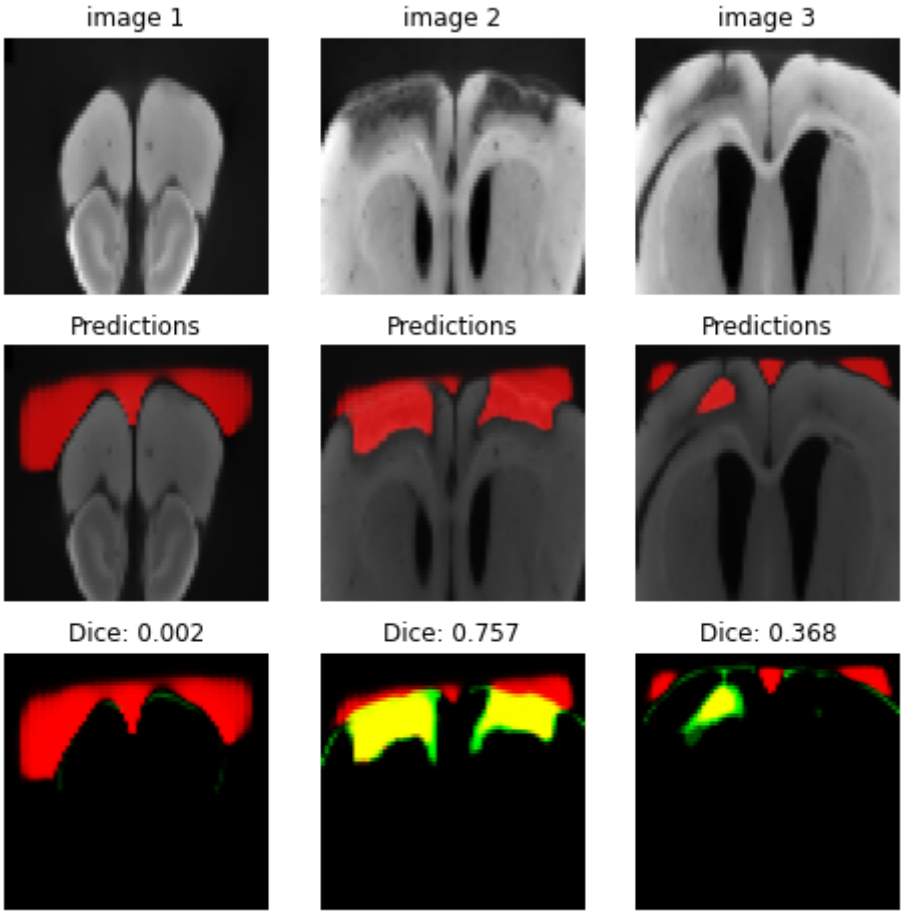

```
# load best model
model.load_weights('ResUnet.h5')


# training set performance
for data_batch, labels_batch in train_generator:
        print('data batch shape:', data_batch.shape)
        print('labels batch shape:', labels_batch.shape)
        break

predict_batch = model.predict_on_batch(data_batch)

check_masks(data_batch, labels_batch, predict_batch)
```

```
data batch shape: (32, 128, 64, 1)
labels batch shape: (32, 128, 64, 1)
```



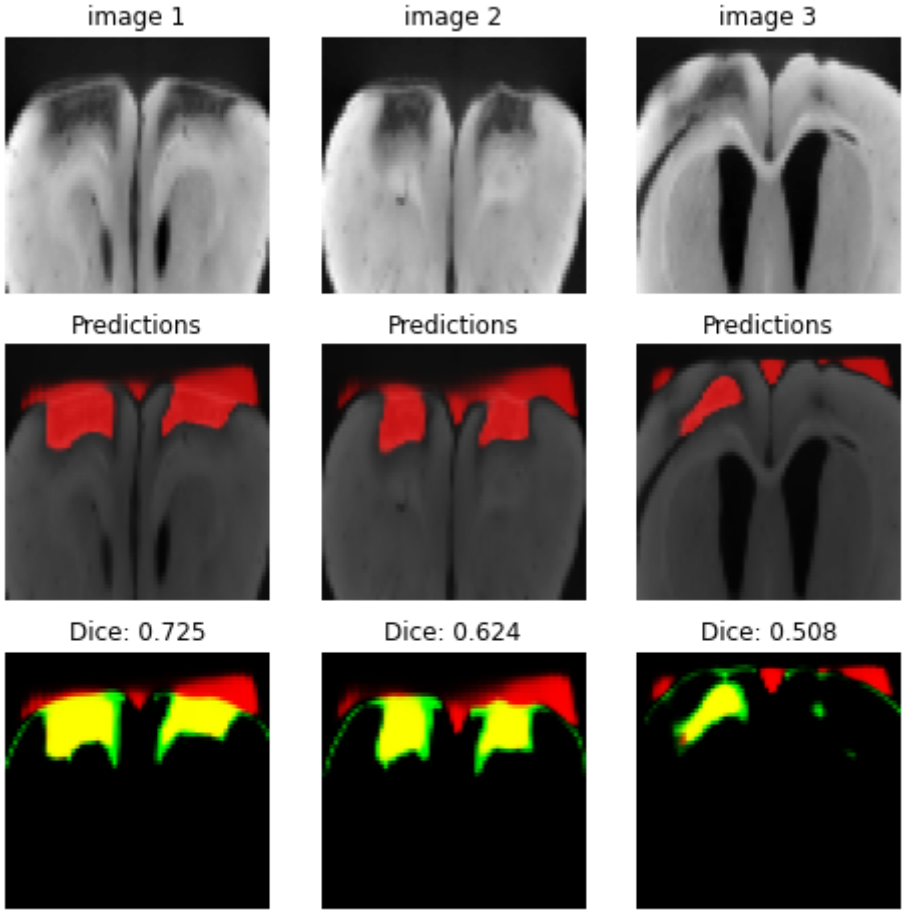
```
# validation set performance
for data_batch, labels_batch in valid_generator:
        print('data batch shape:', data_batch.shape)
        print('labels batch shape:', labels_batch.shape)
        break

predict_batch = model.predict_on_batch(data_batch)

check_masks(data_batch, labels_batch, predict_batch)
```

```
data batch shape: (32, 128, 64, 1)
labels batch shape: (32, 128, 64, 1)
```




```
# test set performance
for data_batch, labels_batch in test_generator:
        print('data batch shape:', data_batch.shape)
        print('labels batch shape:', labels_batch.shape)
        break

predict_batch = model.predict_on_batch(data_batch)

check_masks(data_batch, labels_batch, predict_batch)
```

```
data batch shape: (15, 128, 64, 1)
labels batch shape: (15, 128, 64, 1)
```



✓ 1 秒 完成时间：下午6:39