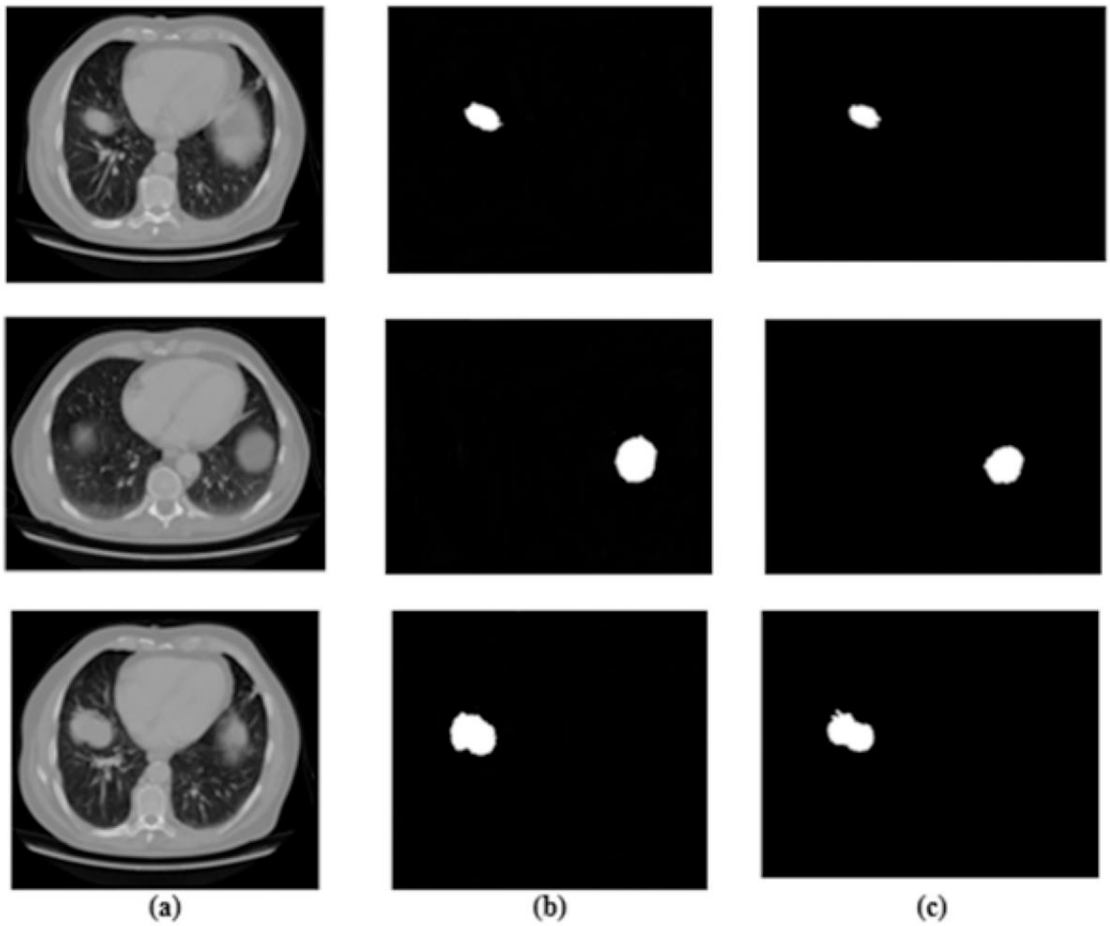
Lung Tumor Segmentation using Unet and Novel Inception Based Unet




```
import pandas as pd
import numpy as np
import os

import warnings
warnings.filterwarnings('ignore')

image_dir = "/kaggle/input/pidata-new-names/Dataset/Images"
mask_dir = "/kaggle/input/pidata-new-names/Dataset/Annotations"

image_files = [f for f in os.listdir(image_dir) if f.endswith('.png')]
mask_files = [f for f in os.listdir(mask_dir) if f.endswith('.png')]

common_files = set([os.path.splitext(f)[0] for f in image_files]) &
set([os.path.splitext(f)[0] for f in mask_files])

image_paths = [os.path.join(image_dir, f + '.png') for f in common_files]
mask_paths = [os.path.join(mask_dir, f + '.png') for f in common_files]
```

```
df = pd.DataFrame({
    'image_path': image_paths,
    'mask_path': mask_paths
})
```

```
df
```

```
                                             image_path  \
0     /kaggle/input/pidata-new-names/Dataset/Images/...
1     /kaggle/input/pidata-new-names/Dataset/Images/...
2     /kaggle/input/pidata-new-names/Dataset/Images/...
3     /kaggle/input/pidata-new-names/Dataset/Images/...
4     /kaggle/input/pidata-new-names/Dataset/Images/...
...                                                 ...
2529  /kaggle/input/pidata-new-names/Dataset/Images/...
2530  /kaggle/input/pidata-new-names/Dataset/Images/...
2531  /kaggle/input/pidata-new-names/Dataset/Images/...
2532  /kaggle/input/pidata-new-names/Dataset/Images/...
2533  /kaggle/input/pidata-new-names/Dataset/Images/...

                                              mask_path
0     /kaggle/input/pidata-new-names/Dataset/Annotat...
1     /kaggle/input/pidata-new-names/Dataset/Annotat...
2     /kaggle/input/pidata-new-names/Dataset/Annotat...
3     /kaggle/input/pidata-new-names/Dataset/Annotat...
4     /kaggle/input/pidata-new-names/Dataset/Annotat...
...                                                 ...
2529  /kaggle/input/pidata-new-names/Dataset/Annotat...
2530  /kaggle/input/pidata-new-names/Dataset/Annotat...
2531  /kaggle/input/pidata-new-names/Dataset/Annotat...
2532  /kaggle/input/pidata-new-names/Dataset/Annotat...
2533  /kaggle/input/pidata-new-names/Dataset/Annotat...

[2534 rows x 2 columns]
```

```
import matplotlib.pyplot as plt
from PIL import Image

plt.figure(figsize=(15, 10))
for i in range(5):

    img = np.array(Image.open(df['image_path'].iloc[i]))
    mask = np.array(Image.open(df['mask_path'].iloc[i]))


    plt.subplot(5, 2, 2*i+1)
    plt.imshow(img, cmap='gray')
    plt.title(f'Image {os.path.basename(df["image_path"].iloc[i])}')
    plt.axis('off')
```

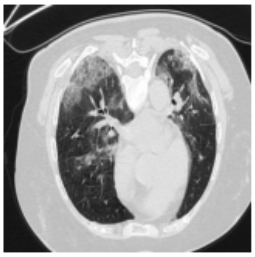
```
    plt.subplot(5, 2, 2*i+2)
    plt.imshow(mask, cmap='gray')
    plt.title(f'Mask {os.path.basename(df["mask_path"].iloc[i])}')
    plt.axis('off')

plt.tight_layout()
plt.show()
```

Image 1730.png

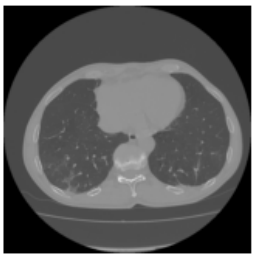
Mask 1730.png

Image 1601.png



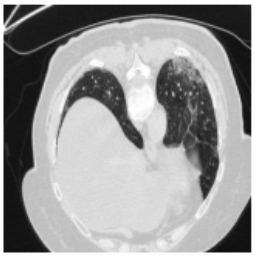
Mask 1601.png

Image 2038.png



Mask 2038.png

Image 1576.png



Mask 1576.png

Image 1474.png

Mask 1474.png

```
import os
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
from PIL import Image
```

```
import tensorflow as tf
from tensorflow.keras import layers, models
from sklearn.model_selection import train_test_split

def dice_score(y_true, y_pred):
    y_true_f = tf.keras.backend.flatten(y_true)
    y_pred_f = tf.keras.backend.flatten(y_pred)
    intersection = tf.keras.backend.sum(y_true_f * y_pred_f)
    return (2. * intersection + 1.) / (tf.keras.backend.sum(y_true_f) +
tf.keras.backend.sum(y_pred_f) + 1.)

def iou(y_true, y_pred):
    y_true_f = tf.keras.backend.flatten(y_true)
    y_pred_f = tf.keras.backend.flatten(y_pred)
    intersection = tf.keras.backend.sum(y_true_f * y_pred_f)
    union = tf.keras.backend.sum(y_true_f) + tf.keras.backend.sum(y_pred_f) -
intersection
    return (intersection + 1.) / (union + 1.)

def unet_model(input_size=(256, 256, 1)):
    inputs = layers.Input(input_size)

    c1 = layers.Conv2D(64, 3, activation='relu', padding='same')(inputs)
    c1 = layers.Conv2D(64, 3, activation='relu', padding='same')(c1)
    p1 = layers.MaxPooling2D((2, 2))(c1)

    c2 = layers.Conv2D(128, 3, activation='relu', padding='same')(p1)
    c2 = layers.Conv2D(128, 3, activation='relu', padding='same')(c2)
    p2 = layers.MaxPooling2D((2, 2))(c2)

    c3 = layers.Conv2D(256, 3, activation='relu', padding='same')(p2)
    c3 = layers.Conv2D(256, 3, activation='relu', padding='same')(c3)
    p3 = layers.MaxPooling2D((2, 2))(c3)

    c4 = layers.Conv2D(512, 3, activation='relu', padding='same')(p3)
    c4 = layers.Conv2D(512, 3, activation='relu', padding='same')(c4)
    p4 = layers.MaxPooling2D((2, 2))(c4)

    c5 = layers.Conv2D(1024, 3, activation='relu', padding='same')(p4)
    c5 = layers.Conv2D(1024, 3, activation='relu', padding='same')(c5)

    u6 = layers.Conv2DTranspose(512, 2, strides=(2, 2), padding='same')(c5)
    u6 = layers.concatenate([u6, c4])
    c6 = layers.Conv2D(512, 3, activation='relu', padding='same')(u6)
    c6 = layers.Conv2D(512, 3, activation='relu', padding='same')(c6)

    u7 = layers.Conv2DTranspose(256, 2, strides=(2, 2), padding='same')(c6)
    u7 = layers.concatenate([u7, c3])
    c7 = layers.Conv2D(256, 3, activation='relu', padding='same')(u7)
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```
    c7 = layers.Conv2D(256, 3, activation='relu', padding='same')(c7)

    u8 = layers.Conv2DTranspose(128, 2, strides=(2, 2), padding='same')(c7)
    u8 = layers.concatenate([u8, c2])
    c8 = layers.Conv2D(128, 3, activation='relu', padding='same')(u8)
    c8 = layers.Conv2D(128, 3, activation='relu', padding='same')(c8)

    u9 = layers.Conv2DTranspose(64, 2, strides=(2, 2), padding='same')(c8)
    u9 = layers.concatenate([u9, c1])
    c9 = layers.Conv2D(64, 3, activation='relu', padding='same')(u9)
    c9 = layers.Conv2D(64, 3, activation='relu', padding='same')(c9)

    outputs = layers.Conv2D(1, 1, activation='sigmoid')(c9)

    model = models.Model(inputs, outputs)
    return model

def load_image_mask(img_path, mask_path, target_size=(256, 256)):
    img = Image.open(img_path).convert('L').resize(target_size)
    img = np.array(img) / 255.0
    mask = Image.open(mask_path).convert('L').resize(target_size)
    mask = np.array(mask) / 255.0
    mask = (mask > 0.5).astype(np.float32)  # Binarize mask
    return img[..., np.newaxis], mask[..., np.newaxis]

images, masks = [], []
for img_path, mask_path in zip(df['image_path'], df['mask_path']):
    img, mask = load_image_mask(img_path, mask_path)
    images.append(img)
    masks.append(mask)

images = np.array(images)
masks = np.array(masks)

X_train, X_test, y_train, y_test = train_test_split(images, masks,
test_size=0.2, random_state=42)

model = unet_model()
model.compile(optimizer='adam', loss='binary_crossentropy',
metrics=[dice_score, iou])

history = model.fit(X_train, y_train, validation_data=(X_test, y_test),
epochs=20, batch_size=16)

plt.figure(figsize=(15, 5))

plt.subplot(1, 3, 1)
plt.plot(history.history['loss'], label='Train Loss')
plt.plot(history.history['val_loss'], label='Val Loss')
```

```
plt.title('Loss')
plt.xlabel('Epoch')
plt.ylabel('Loss')
plt.legend()

plt.subplot(1, 3, 2)
plt.plot(history.history['dice_score'], label='Train Dice')
plt.plot(history.history['val_dice_score'], label='Val Dice')
plt.title('Dice Score')
plt.xlabel('Epoch')
plt.ylabel('Dice Score')
plt.legend()

plt.subplot(1, 3, 3)
plt.plot(history.history['iou'], label='Train IoU')
plt.plot(history.history['val_iou'], label='Val IoU')
plt.title('IoU')
plt.xlabel('Epoch')
plt.ylabel('IoU')
plt.legend()

plt.tight_layout()
plt.show()

predictions = model.predict(X_test[:5])

plt.figure(figsize=(15, 10))
for i in range(5):
    plt.subplot(5, 3, 3*i+1)
    plt.imshow(X_test[i].squeeze(), cmap='gray')
    plt.title(f'Image {i+1}')
    plt.axis('off')

    plt.subplot(5, 3, 3*i+2)
    plt.imshow(y_test[i].squeeze(), cmap='gray')
    plt.title(f'Original Mask {i+1}')
    plt.axis('off')

    plt.subplot(5, 3, 3*i+3)
    plt.imshow(predictions[i].squeeze() > 0.5, cmap='gray')
    plt.title(f'Predicted Mask {i+1}')
    plt.axis('off')

plt.tight_layout()
plt.show()
```

```
2025-07-15 09:01:07.130550: E
external/local_xla/xla/stream_executor/cuda/cuda_fft.cc:477] Unable to
register cuFFT factory: Attempting to register factory for plugin cuFFT when
```

```
one has already been registered
WARNING: All log messages before absl::InitializeLog() is called are written
to STDERR
E0000 00:00:1752570067.316157      36 cuda_dnn.cc:8310] Unable to register
cuDNN factory: Attempting to register factory for plugin cuDNN when one has
already been registered
E0000 00:00:1752570067.370811      36 cuda_blas.cc:1418] Unable to register
cuBLAS factory: Attempting to register factory for plugin cuBLAS when one has
already been registered
I0000 00:00:1752570141.539373      36 gpu_device.cc:2022] Created device
/job:localhost/replica:0/task:0/device:GPU:0 with 13942 MB memory:  ->
device: 0, name: Tesla T4, pci bus id: 0000:00:04.0, compute capability: 7.5
I0000 00:00:1752570141.539987      36 gpu_device.cc:2022] Created device
/job:localhost/replica:0/task:0/device:GPU:1 with 13942 MB memory:  ->
device: 1, name: Tesla T4, pci bus id: 0000:00:05.0, compute capability: 7.5

Epoch 1/20

WARNING: All log messages before absl::InitializeLog() is called are written
to STDERR
I0000 00:00:1752570154.623489     100 service.cc:148] XLA service
0x7e40c400ad50 initialized for platform CUDA (this does not guarantee that
XLA will be used). Devices:
I0000 00:00:1752570154.624281     100 service.cc:156]   StreamExecutor device
(0): Tesla T4, Compute Capability 7.5
I0000 00:00:1752570154.624302     100 service.cc:156]   StreamExecutor device
(1): Tesla T4, Compute Capability 7.5
I0000 00:00:1752570155.634385     100 cuda_dnn.cc:529] Loaded cuDNN version
90300
2025-07-15 09:02:41.922430: E
external/local_xla/xla/service/slow_operation_alarm.cc:65] Trying algorithm
eng12{k11=0} for conv (f32[16,128,128,128]{3,2,1,0}, u8[0]{0}) custom-
call(f32[16,128,128,128]{3,2,1,0}, f32[128,128,3,3]{3,2,1,0}, f32[128]{0}),
window={size=3x3 pad=1_1x1_1}, dim_labels=bf01_oi01->bf01,
custom_call_target="__cudnn$convBiasActivationForward",
backend_config={"cudnn_conv_backend_config":{"activation_mode":"kNone","conv_
result_scale":1,"leakyrelu_alpha":0,"side_input_scale":0},"force_earliest_sch
edule":false,"operation_queue_id":"0","wait_on_operation_queues":[]} is
taking a while...
2025-07-15 09:02:42.078212: E
external/local_xla/xla/service/slow_operation_alarm.cc:133] The operation
took 1.155882675s
Trying algorithm eng12{k11=0} for conv (f32[16,128,128,128]{3,2,1,0},
u8[0]{0}) custom-call(f32[16,128,128,128]{3,2,1,0},
f32[128,128,3,3]{3,2,1,0}, f32[128]{0}), window={size=3x3 pad=1_1x1_1},
dim_labels=bf01_oi01->bf01,
custom_call_target="__cudnn$convBiasActivationForward",
backend_config={"cudnn_conv_backend_config":{"activation_mode":"kNone","conv_
result_scale":1,"leakyrelu_alpha":0,"side_input_scale":0},"force_earliest_sch
edule":false,"operation_queue_id":"0","wait_on_operation_queues":[]} is
```

```
taking a while...
I0000 00:00:1752570243.446324     100 device_compiler.h:188] Compiled cluster
using XLA!  This line is logged at most once for the lifetime of the process.

126/127 ━━━━━━━━━━━━━━━━━━━━0s 986ms/step - dice_score: 0.0198 - iou: 0.0100
- loss: 0.2509

E0000 00:00:1752570388.266540     100 gpu_timer.cc:82] Delay kernel timed
out: measured time has sub-optimal accuracy. There may be a missing warmup
execution, please investigate in Nsight Systems.
E0000 00:00:1752570388.513959     100 gpu_timer.cc:82] Delay kernel timed
out: measured time has sub-optimal accuracy. There may be a missing warmup
execution, please investigate in Nsight Systems.
E0000 00:00:1752570398.384847     100 gpu_timer.cc:82] Delay kernel timed
out: measured time has sub-optimal accuracy. There may be a missing warmup
execution, please investigate in Nsight Systems.
E0000 00:00:1752570398.733560     100 gpu_timer.cc:82] Delay kernel timed
out: measured time has sub-optimal accuracy. There may be a missing warmup
execution, please investigate in Nsight Systems.
E0000 00:00:1752570410.503368     100 gpu_timer.cc:82] Delay kernel timed
out: measured time has sub-optimal accuracy. There may be a missing warmup
execution, please investigate in Nsight Systems.
E0000 00:00:1752570410.756161     100 gpu_timer.cc:82] Delay kernel timed
out: measured time has sub-optimal accuracy. There may be a missing warmup
execution, please investigate in Nsight Systems.

127/127 ━━━━━━━━━━━━━━━━━━━━351s 2s/step - dice_score: 0.0198 - iou: 0.0101
- loss: 0.2490 - val_dice_score: 0.0285 - val_iou: 0.0145 - val_loss: 0.0697
Epoch 2/20
127/127 ━━━━━━━━━━━━━━━━━━━━137s 1s/step - dice_score: 0.0277 - iou: 0.0141
- loss: 0.0742 - val_dice_score: 0.0260 - val_iou: 0.0132 - val_loss: 0.0687
Epoch 3/20
127/127 ━━━━━━━━━━━━━━━━━━━━137s 1s/step - dice_score: 0.0306 - iou: 0.0155
- loss: 0.0715 - val_dice_score: 0.0440 - val_iou: 0.0225 - val_loss: 0.0611
Epoch 4/20
127/127 ━━━━━━━━━━━━━━━━━━━━138s 1s/step - dice_score: 0.0550 - iou: 0.0283
- loss: 0.0613 - val_dice_score: 0.0618 - val_iou: 0.0320 - val_loss: 0.0584
Epoch 5/20
127/127 ━━━━━━━━━━━━━━━━━━━━137s 1s/step - dice_score: 0.0735 - iou: 0.0382
- loss: 0.0571 - val_dice_score: 0.0816 - val_iou: 0.0427 - val_loss: 0.0563
Epoch 6/20
127/127 ━━━━━━━━━━━━━━━━━━━━137s 1s/step - dice_score: 0.0814 - iou: 0.0426
- loss: 0.0582 - val_dice_score: 0.1193 - val_iou: 0.0636 - val_loss: 0.0516
Epoch 7/20
127/127 ━━━━━━━━━━━━━━━━━━━━137s 1s/step - dice_score: 0.1299 - iou: 0.0700
- loss: 0.0508 - val_dice_score: 0.2327 - val_iou: 0.1323 - val_loss: 0.0419
Epoch 8/20
127/127 ━━━━━━━━━━━━━━━━━━━━138s 1s/step - dice_score: 0.2364 - iou: 0.1357
- loss: 0.0417 - val_dice_score: 0.2149 - val_iou: 0.1209 - val_loss: 0.0404
Epoch 9/20
```

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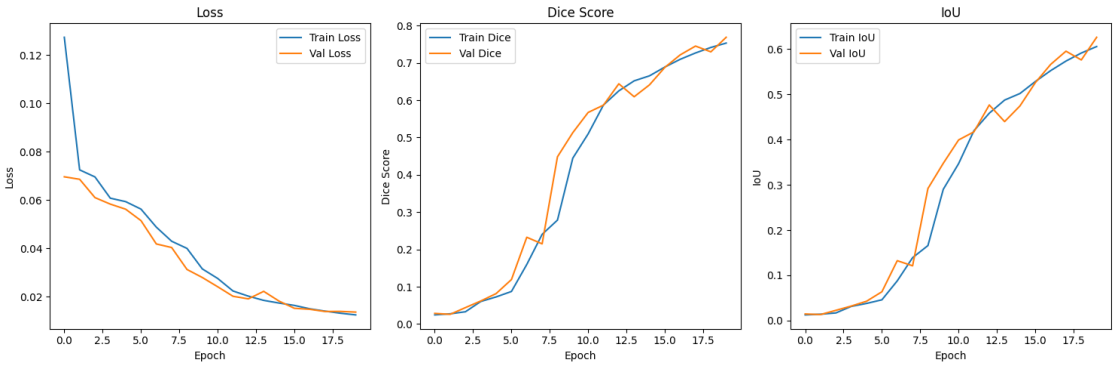
127/127 ━━━━━━━━━━━━━━━━━━━━137s 1s/step - dice_score: 0.2456 - iou: 0.1425
- loss: 0.0430 - val_dice_score: 0.4484 - val_iou: 0.2919 - val_loss: 0.0313
Epoch 10/20
127/127 ━━━━━━━━━━━━━━━━━━━━137s 1s/step - dice_score: 0.4143 - iou: 0.2644
- loss: 0.0319 - val_dice_score: 0.5131 - val_iou: 0.3476 - val_loss: 0.0280
Epoch 11/20
127/127 ━━━━━━━━━━━━━━━━━━━━137s 1s/step - dice_score: 0.5167 - iou: 0.3528
- loss: 0.0280 - val_dice_score: 0.5673 - val_iou: 0.3993 - val_loss: 0.0242
Epoch 12/20
127/127 ━━━━━━━━━━━━━━━━━━━━137s 1s/step - dice_score: 0.5718 - iou: 0.4041
- loss: 0.0247 - val_dice_score: 0.5869 - val_iou: 0.4172 - val_loss: 0.0202
Epoch 13/20
127/127 ━━━━━━━━━━━━━━━━━━━━137s 1s/step - dice_score: 0.6274 - iou: 0.4608
- loss: 0.0205 - val_dice_score: 0.6441 - val_iou: 0.4766 - val_loss: 0.0192
Epoch 14/20
127/127 ━━━━━━━━━━━━━━━━━━━━137s 1s/step - dice_score: 0.6739 - iou: 0.5102
- loss: 0.0176 - val_dice_score: 0.6094 - val_iou: 0.4398 - val_loss: 0.0223
Epoch 15/20
127/127 ━━━━━━━━━━━━━━━━━━━━136s 1s/step - dice_score: 0.6462 - iou: 0.4809
- loss: 0.0184 - val_dice_score: 0.6413 - val_iou: 0.4745 - val_loss: 0.0183
Epoch 16/20
127/127 ━━━━━━━━━━━━━━━━━━━━136s 1s/step - dice_score: 0.6651 - iou: 0.5013
- loss: 0.0181 - val_dice_score: 0.6881 - val_iou: 0.5259 - val_loss: 0.0153
Epoch 17/20
127/127 ━━━━━━━━━━━━━━━━━━━━137s 1s/step - dice_score: 0.7038 - iou: 0.5451
- loss: 0.0165 - val_dice_score: 0.7216 - val_iou: 0.5662 - val_loss: 0.0149
Epoch 18/20
127/127 ━━━━━━━━━━━━━━━━━━━━137s 1s/step - dice_score: 0.7297 - iou: 0.5773
- loss: 0.0148 - val_dice_score: 0.7453 - val_iou: 0.5955 - val_loss: 0.0139
Epoch 19/20
127/127 ━━━━━━━━━━━━━━━━━━━━138s 1s/step - dice_score: 0.7484 - iou: 0.6002
- loss: 0.0131 - val_dice_score: 0.7298 - val_iou: 0.5762 - val_loss: 0.0140
Epoch 20/20
127/127 ━━━━━━━━━━━━━━━━━━━━137s 1s/step - dice_score: 0.7469 - iou: 0.5978
- loss: 0.0123 - val_dice_score: 0.7688 - val_iou: 0.6262 - val_loss: 0.0137
```




```
E0000 00:00:1752573113.974831     103 gpu_timer.cc:82] Delay kernel timed
out: measured time has sub-optimal accuracy. There may be a missing warmup
execution, please investigate in Nsight Systems.
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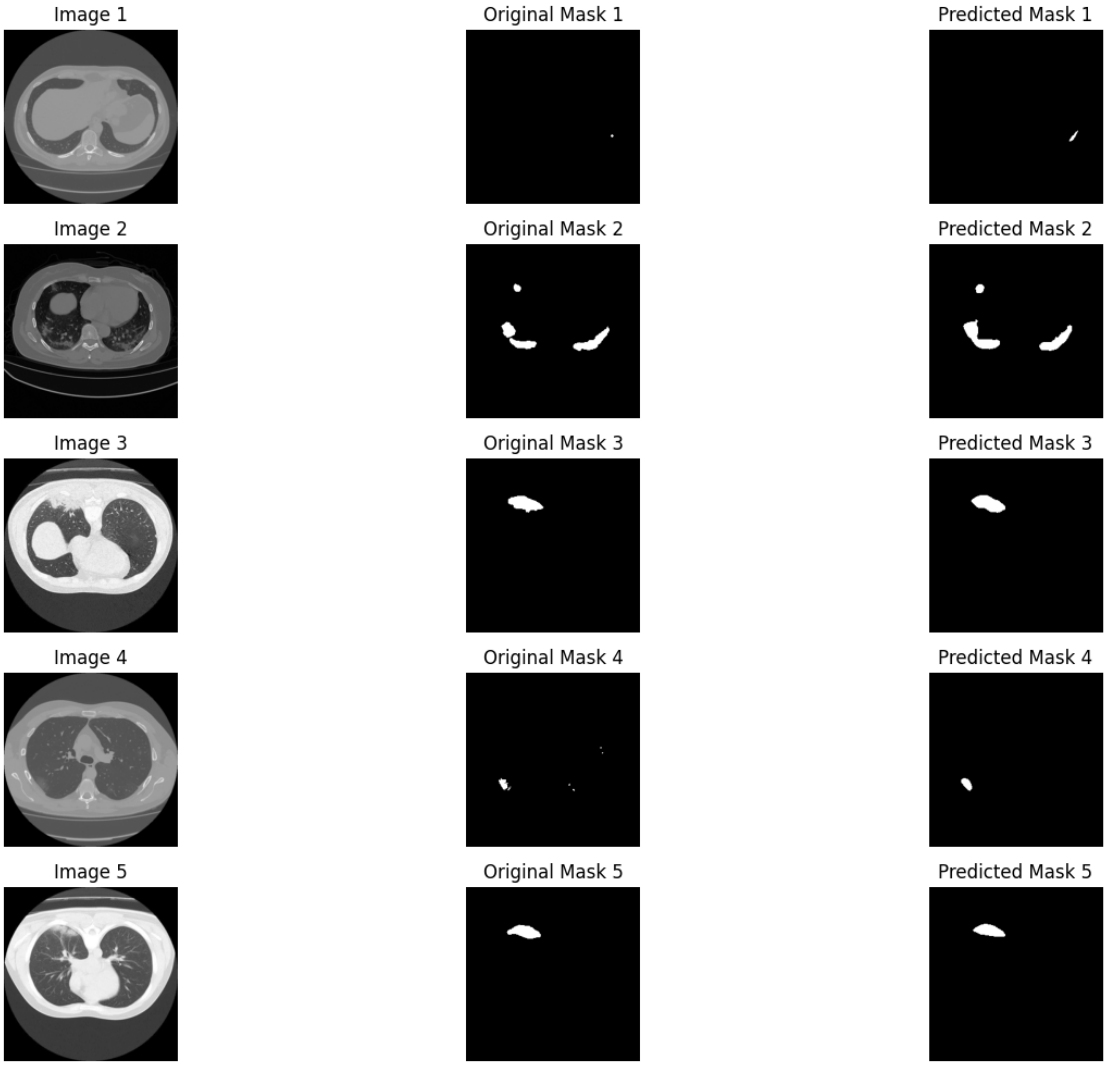
```
E0000 00:00:1752573114.213921     103 gpu_timer.cc:82] Delay kernel timed
out: measured time has sub-optimal accuracy. There may be a missing warmup
execution, please investigate in Nsight Systems.

1/1 ━━━━━━━━━━━━━━━━━━━━16s 16s/step
```




```
model.summary()
```

```
Model: "functional"
```

Layer (type)	Output Shape	Param #	Connected to
input_layer (InputLayer)	(None, 256, 256, 1)	0	-
conv2d (Conv2D)	(None, 256, 256, 64)	640	input_layer[0][0]

conv2d_1 (Conv2D)	(None, 256, 256, 64)	36,928	conv2d[0][0]
max_pooling2d (MaxPooling2D)	(None, 128, 128, 64)	0	conv2d_1[0][0]
conv2d_2 (Conv2D)	(None, 128, 128, 128)	73,856	max_pooling2d[0]…
conv2d_3 (Conv2D)	(None, 128, 128, 128)	147,584	conv2d_2[0][0]
max_pooling2d_1 (MaxPooling2D)	(None, 64, 64, 128)	0	conv2d_3[0][0]
conv2d_4 (Conv2D)	(None, 64, 64, 256)	295,168	max_pooling2d_1[…
conv2d_5 (Conv2D)	(None, 64, 64, 256)	590,080	conv2d_4[0][0]
max_pooling2d_2 (MaxPooling2D)	(None, 32, 32, 256)	0	conv2d_5[0][0]
conv2d_6 (Conv2D)	(None, 32, 32, 512)	1,180,160	max_pooling2d_2[…
conv2d_7 (Conv2D)	(None, 32, 32, 512)	2,359,808	conv2d_6[0][0]
max_pooling2d_3 (MaxPooling2D)	(None, 16, 16, 512)	0	conv2d_7[0][0]
conv2d_8 (Conv2D)	(None, 16, 16, 1024)	4,719,616	max_pooling2d_3[…
conv2d_9 (Conv2D)	(None, 16, 16, 1024)	9,438,208	conv2d_8[0][0]
conv2d_transpose (Conv2DTranspose)	(None, 32, 32, 512)	2,097,664	conv2d_9[0][0]
concatenate (Concatenate)	(None, 32, 32, 1024)	0	conv2d_transpose… conv2d_7[0][0]
conv2d_10 (Conv2D)	(None, 32, 32, 512)	4,719,104	concatenate[0][0]
conv2d_11 (Conv2D)	(None, 32, 32, 512)	2,359,808	conv2d_10[0][0]

conv2d_transpose_1 (Conv2DTranspose)	(None, 64, 64, 256)	524,544	conv2d_11[0][0]
concatenate_1 (Concatenate)	(None, 64, 64, 512)	0	conv2d_transpose… conv2d_5[0][0]
conv2d_12 (Conv2D)	(None, 64, 64, 256)	1,179,904	concatenate_1[0]…
conv2d_13 (Conv2D)	(None, 64, 64, 256)	590,080	conv2d_12[0][0]
conv2d_transpose_2 (Conv2DTranspose)	(None, 128, 128, 128)	131,200	conv2d_13[0][0]
concatenate_2 (Concatenate)	(None, 128, 128, 256)	0	conv2d_transpose… conv2d_3[0][0]
conv2d_14 (Conv2D)	(None, 128, 128, 128)	295,040	concatenate_2[0]…
conv2d_15 (Conv2D)	(None, 128, 128, 128)	147,584	conv2d_14[0][0]
conv2d_transpose_3 (Conv2DTranspose)	(None, 256, 256, 64)	32,832	conv2d_15[0][0]
concatenate_3 (Concatenate)	(None, 256, 256, 128)	0	conv2d_transpose… conv2d_1[0][0]
conv2d_16 (Conv2D)	(None, 256, 256, 64)	73,792	concatenate_3[0]…
conv2d_17 (Conv2D)	(None, 256, 256, 64)	36,928	conv2d_16[0][0]
conv2d_18 (Conv2D)	(None, 256, 256, 1)	65	conv2d_17[0][0]

Total params: 93,091,781 (355.12 MB)

Trainable params: 31,030,593 (118.37 MB)

Non-trainable params: 0 (0.00 B)

Optimizer params: 62,061,188 (236.74 MB)

```
from tensorflow.keras.utils import plot_model
plot_model(model, to_file='model.png', show_shapes=True,
show_layer_names=True)
```

```
import os
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
from PIL import Image
import tensorflow as tf
from tensorflow.keras import layers, models
from sklearn.model_selection import train_test_split

def dice_score(y_true, y_pred):
    y_true_f = tf.keras.backend.flatten(y_true)
    y_pred_f = tf.keras.backend.flatten(y_pred)
    intersection = tf.keras.backend.sum(y_true_f * y_pred_f)
    return (2. * intersection + 1.) / (tf.keras.backend.sum(y_true_f) +
tf.keras.backend.sum(y_pred_f) + 1.)

def iou(y_true, y_pred):
    y_true_f = tf.keras.backend.flatten(y_true)
    y_pred_f = tf.keras.backend.flatten(y_pred)
    intersection = tf.keras.backend.sum(y_true_f * y_pred_f)
    union = tf.keras.backend.sum(y_true_f) + tf.keras.backend.sum(y_pred_f) -
intersection
    return (intersection + 1.) / (union + 1.)

def inception_module(x, filters):
    f1, f3, f5, f_pool = filters // 4, filters // 2, filters // 4, filters //
4

    conv1 = layers.Conv2D(f1, 1, activation='relu', padding='same')(x)

    conv3 = layers.Conv2D(f3, 1, activation='relu', padding='same')(x)
    conv3 = layers.Conv2D(f3, 3, activation='relu', padding='same')(conv3)

    conv5 = layers.Conv2D(f5, 1, activation='relu', padding='same')(x)
    conv5 = layers.Conv2D(f5, 5, activation='relu', padding='same')(conv5)

    pool = layers.MaxPooling2D(3, strides=1, padding='same')(x)
    pool = layers.Conv2D(f_pool, 1, activation='relu', padding='same')(pool)

    output = layers.concatenate([conv1, conv3, conv5, pool], axis=-1)
    return output

def inception_unet(input_size=(256, 256, 1)):
    inputs = layers.Input(input_size)
```

```
    c1 = inception_module(inputs, 64)
    p1 = layers.MaxPooling2D((2, 2))(c1)

    c2 = inception_module(p1, 128)
    p2 = layers.MaxPooling2D((2, 2))(c2)

    c3 = inception_module(p2, 256)
    p3 = layers.MaxPooling2D((2, 2))(c3)

    c4 = inception_module(p3, 512)
    p4 = layers.MaxPooling2D((2, 2))(c4)

    c5 = inception_module(p4, 512)

    u6 = layers.Conv2DTranspose(256, 2, strides=(2, 2), padding='same')(c5)
    u6 = layers.concatenate([u6, c4])
    c6 = inception_module(u6, 256)

    u7 = layers.Conv2DTranspose(128, 2, strides=(2, 2), padding='same')(c6)
    u7 = layers.concatenate([u7, c3])
    c7 = inception_module(u7, 128)

    u8 = layers.Conv2DTranspose(64, 2, strides=(2, 2), padding='same')(c7)
    u8 = layers.concatenate([u8, c2])
    c8 = inception_module(u8, 64)

    u9 = layers.Conv2DTranspose(32, 2, strides=(2, 2), padding='same')(c8)
    u9 = layers.concatenate([u9, c1])
    c9 = inception_module(u9, 32)

    outputs = layers.Conv2D(1, 1, activation='sigmoid')(c9)

    model = models.Model(inputs, outputs)
    return model

def load_image_mask(img_path, mask_path, target_size=(256, 256)):
    img = Image.open(img_path).convert('L').resize(target_size)
    img = np.array(img) / 255.0
    mask = Image.open(mask_path).convert('L').resize(target_size)
    mask = np.array(mask) / 255.0
    mask = (mask > 0.5).astype(np.float32)  # Binarize mask
    return img[..., np.newaxis], mask[..., np.newaxis]

images, masks = [], []
for img_path, mask_path in zip(df['image_path'], df['mask_path']):
    img, mask = load_image_mask(img_path, mask_path)
    images.append(img)
    masks.append(mask)
```

```
images = np.array(images)
masks = np.array(masks)

X_train, X_test, y_train, y_test = train_test_split(images, masks,
test_size=0.2, random_state=42)

model = inception_unet()
model.compile(optimizer='adam', loss='binary_crossentropy',
metrics=[dice_score, iou])

history = model.fit(X_train, y_train, validation_data=(X_test, y_test),
epochs=5, batch_size=16)

plt.figure(figsize=(15, 5))

plt.subplot(1, 3, 1)
plt.plot(history.history['loss'], label='Train Loss')
plt.plot(history.history['val_loss'], label='Val Loss')
plt.title('Loss')
plt.xlabel('Epoch')
plt.ylabel('Loss')
plt.legend()

plt.subplot(1, 3, 2)
plt.plot(history.history['dice_score'], label='Train Dice')
plt.plot(history.history['val_dice_score'], label='Val Dice')
plt.title('Dice Score')
plt.xlabel('Epoch')
plt.ylabel('Dice Score')
plt.legend()

plt.subplot(1, 3, 3)
plt.plot(history.history['iou'], label='Train IoU')
plt.plot(history.history['val_iou'], label='Val IoU')
plt.title('IoU')
plt.xlabel('Epoch')
plt.ylabel('IoU')
plt.legend()

plt.tight_layout()
plt.show()

predictions = model.predict(X_test[:5])

plt.figure(figsize=(15, 10))
for i in range(5):
    plt.subplot(5, 3, 3*i+1)
    plt.imshow(X_test[i].squeeze(), cmap='gray')
```

```
    plt.title(f'Image {i+1}')
    plt.axis('off')

    plt.subplot(5, 3, 3*i+2)
    plt.imshow(y_test[i].squeeze(), cmap='gray')
    plt.title(f'Original Mask {i+1}')
    plt.axis('off')

    plt.subplot(5, 3, 3*i+3)
    plt.imshow(predictions[i].squeeze() > 0.5, cmap='gray')
    plt.title(f'Predicted Mask {i+1}')
    plt.axis('off')

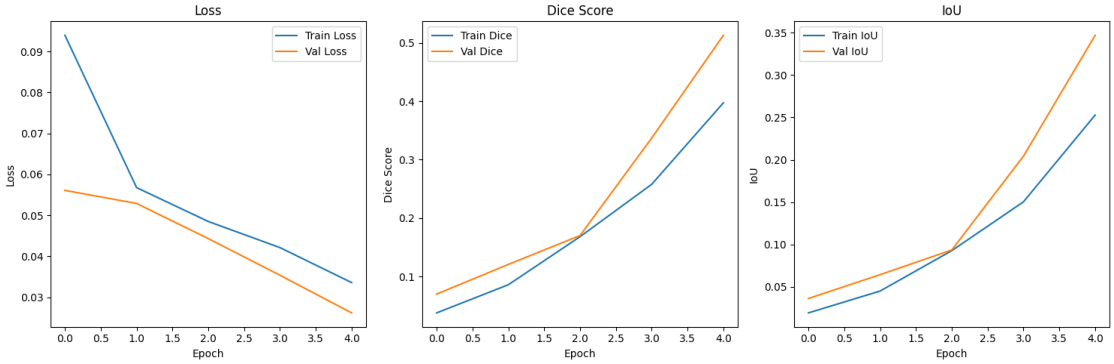
plt.tight_layout()
plt.show()
```

```
Epoch 1/5

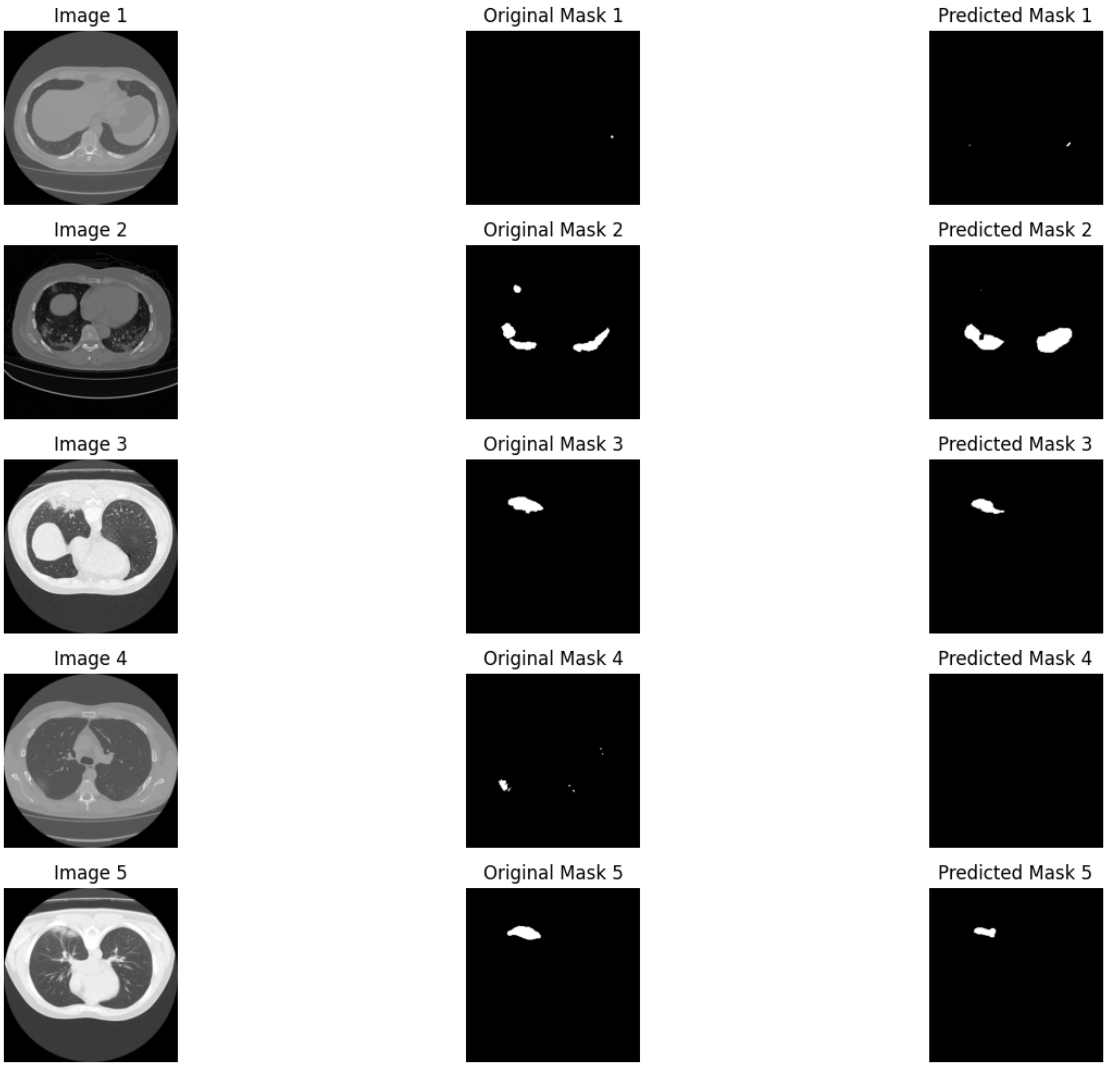
2025-07-15 10:00:19.331103: E
external/local_xla/xla/service/slow_operation_alarm.cc:65] Trying algorithm
eng0{} for conv (f32[32,32,3,3]{3,2,1,0}, u8[0]{0}) custom-
call(f32[16,32,256,256]{3,2,1,0}, f32[16,32,256,256]{3,2,1,0}),
window={size=3x3 pad=1_1x1_1}, dim_labels=bf01_oi01->bf01,
custom_call_target="__cudnn$convBackwardFilter",
backend_config={"cudnn_conv_backend_config":{"activation_mode":"kNone","conv_
result_scale":1,"leakyrelu_alpha":0,"side_input_scale":0},"force_earliest_sch
edule":false,"operation_queue_id":"0","wait_on_operation_queues":[]} is
taking a while...
2025-07-15 10:00:19.447336: E
external/local_xla/xla/service/slow_operation_alarm.cc:133] The operation
took 1.116336069s
Trying algorithm eng0{} for conv (f32[32,32,3,3]{3,2,1,0}, u8[0]{0}) custom-
call(f32[16,32,256,256]{3,2,1,0}, f32[16,32,256,256]{3,2,1,0}),
window={size=3x3 pad=1_1x1_1}, dim_labels=bf01_oi01->bf01,
custom_call_target="__cudnn$convBackwardFilter",
backend_config={"cudnn_conv_backend_config":{"activation_mode":"kNone","conv_
result_scale":1,"leakyrelu_alpha":0,"side_input_scale":0},"force_earliest_sch
edule":false,"operation_queue_id":"0","wait_on_operation_queues":[]} is
taking a while...

127/127 ━━━━━━━━━━━━━━━━━━━━214s 1s/step - dice_score: 0.0244 - iou: 0.0125
- loss: 0.1647 - val_dice_score: 0.0697 - val_iou: 0.0362 - val_loss: 0.0561
Epoch 2/5
127/127 ━━━━━━━━━━━━━━━━━━━━72s 569ms/step - dice_score: 0.0749 - iou:
0.0390 - loss: 0.0581 - val_dice_score: 0.1205 - val_iou: 0.0644 - val_loss:
0.0529
Epoch 3/5
127/127 ━━━━━━━━━━━━━━━━━━━━72s 566ms/step - dice_score: 0.1452 - iou:
0.0791 - loss: 0.0504 - val_dice_score: 0.1700 - val_iou: 0.0935 - val_loss:
0.0443
```

```
Epoch 4/5
127/127 ━━━━━━━━━━━━━━━━━━━━72s 566ms/step - dice_score: 0.2226 - iou:
0.1268 - loss: 0.0446 - val_dice_score: 0.3370 - val_iou: 0.2043 - val_loss:
0.0354
Epoch 5/5
127/127 ━━━━━━━━━━━━━━━━━━━━72s 565ms/step - dice_score: 0.3718 - iou:
0.2333 - loss: 0.0349 - val_dice_score: 0.5129 - val_iou: 0.3470 - val_loss:
0.0262
```




```
1/1 ━━━━━━━━━━━━━━━━━━━━9s 9s/step
```




```
model.summary()
```

```
Model: "functional_1"
```

Layer (type)	Output Shape	Param #	Connected to
input_layer_1 (InputLayer)	(None, 256, 256, 1)	0	-
conv2d_20 (Conv2D)	(None, 256, 256, 32)	64	input_layer_1[0]…
conv2d_22 (Conv2D)	(None, 256, 256, 16)	32	input_layer_1[0]…
max_pooling2d_4 (MaxPooling2D)	(None, 256, 256, 1)	0	input_layer_1[0]…

conv2d_19 (Conv2D)	(None, 256, 256, 16)	32	input_layer_1[0]…
conv2d_21 (Conv2D)	(None, 256, 256, 32)	9,248	conv2d_20[0][0]
conv2d_23 (Conv2D)	(None, 256, 256, 16)	6,416	conv2d_22[0][0]
conv2d_24 (Conv2D)	(None, 256, 256, 16)	32	max_pooling2d_4[…
concatenate_4 (Concatenate)	(None, 256, 256, 80)	0	conv2d_19[0][0], conv2d_21[0][0], conv2d_23[0][0], conv2d_24[0][0]
max_pooling2d_5 (MaxPooling2D)	(None, 128, 128, 80)	0	concatenate_4[0]…
conv2d_26 (Conv2D)	(None, 128, 128, 64)	5,184	max_pooling2d_5[…
conv2d_28 (Conv2D)	(None, 128, 128, 32)	2,592	max_pooling2d_5[…
max_pooling2d_6 (MaxPooling2D)	(None, 128, 128, 80)	0	max_pooling2d_5[…
conv2d_25 (Conv2D)	(None, 128, 128, 32)	2,592	max_pooling2d_5[…
conv2d_27 (Conv2D)	(None, 128, 128, 64)	36,928	conv2d_26[0][0]
conv2d_29 (Conv2D)	(None, 128, 128, 32)	25,632	conv2d_28[0][0]
conv2d_30 (Conv2D)	(None, 128, 128, 32)	2,592	max_pooling2d_6[…
concatenate_5 (Concatenate)	(None, 128, 128, 160)	0	conv2d_25[0][0], conv2d_27[0][0], conv2d_29[0][0], conv2d_30[0][0]
max_pooling2d_7 (MaxPooling2D)	(None, 64, 64, 160)	0	concatenate_5[0]…

conv2d_32 (Conv2D)	(None, 64, 64, 128)	20,608	max_pooling2d_7[…
conv2d_34 (Conv2D)	(None, 64, 64, 64)	10,304	max_pooling2d_7[…
max_pooling2d_8 (MaxPooling2D)	(None, 64, 64, 160)	0	max_pooling2d_7[…
conv2d_31 (Conv2D)	(None, 64, 64, 64)	10,304	max_pooling2d_7[…
conv2d_33 (Conv2D)	(None, 64, 64, 128)	147,584	conv2d_32[0][0]
conv2d_35 (Conv2D)	(None, 64, 64, 64)	102,464	conv2d_34[0][0]
conv2d_36 (Conv2D)	(None, 64, 64, 64)	10,304	max_pooling2d_8[…
concatenate_6 (Concatenate)	(None, 64, 64, 320)	0	conv2d_31[0][0], conv2d_33[0][0], conv2d_35[0][0], conv2d_36[0][0]
max_pooling2d_9 (MaxPooling2D)	(None, 32, 32, 320)	0	concatenate_6[0]…
conv2d_38 (Conv2D)	(None, 32, 32, 256)	82,176	max_pooling2d_9[…
conv2d_40 (Conv2D)	(None, 32, 32, 128)	41,088	max_pooling2d_9[…
max_pooling2d_10 (MaxPooling2D)	(None, 32, 32, 320)	0	max_pooling2d_9[…
conv2d_37 (Conv2D)	(None, 32, 32, 128)	41,088	max_pooling2d_9[…
conv2d_39 (Conv2D)	(None, 32, 32, 256)	590,080	conv2d_38[0][0]
conv2d_41 (Conv2D)	(None, 32, 32, 128)	409,728	conv2d_40[0][0]
conv2d_42 (Conv2D)	(None, 32, 32, 128)	41,088	max_pooling2d_10…

concatenate_7 (Concatenate)	(None, 32, 32, 640)	0	conv2d_37[0][0], conv2d_39[0][0], conv2d_41[0][0], conv2d_42[0][0]
max_pooling2d_11 (MaxPooling2D)	(None, 16, 16, 640)	0	concatenate_7[0]…
conv2d_44 (Conv2D)	(None, 16, 16, 256)	164,096	max_pooling2d_11…
conv2d_46 (Conv2D)	(None, 16, 16, 128)	82,048	max_pooling2d_11…
max_pooling2d_12 (MaxPooling2D)	(None, 16, 16, 640)	0	max_pooling2d_11…
conv2d_43 (Conv2D)	(None, 16, 16, 128)	82,048	max_pooling2d_11…
conv2d_45 (Conv2D)	(None, 16, 16, 256)	590,080	conv2d_44[0][0]
conv2d_47 (Conv2D)	(None, 16, 16, 128)	409,728	conv2d_46[0][0]
conv2d_48 (Conv2D)	(None, 16, 16, 128)	82,048	max_pooling2d_12…
concatenate_8 (Concatenate)	(None, 16, 16, 640)	0	conv2d_43[0][0], conv2d_45[0][0], conv2d_47[0][0], conv2d_48[0][0]
conv2d_transpose_4 (Conv2DTranspose)	(None, 32, 32, 256)	655,616	concatenate_8[0]…
concatenate_9 (Concatenate)	(None, 32, 32, 896)	0	conv2d_transpose… concatenate_7[0]…
conv2d_50 (Conv2D)	(None, 32, 32, 128)	114,816	concatenate_9[0]…
conv2d_52 (Conv2D)	(None, 32, 32, 64)	57,408	concatenate_9[0]…
max_pooling2d_13 (MaxPooling2D)	(None, 32, 32, 896)	0	concatenate_9[0]…
conv2d_49 (Conv2D)	(None, 32, 32,	57,408	concatenate_9[0]…

	64)		
conv2d_51 (Conv2D)	(None, 32, 32, 128)	147,584	conv2d_50[0][0]
conv2d_53 (Conv2D)	(None, 32, 32, 64)	102,464	conv2d_52[0][0]
conv2d_54 (Conv2D)	(None, 32, 32, 64)	57,408	max_pooling2d_13…
concatenate_10 (Concatenate)	(None, 32, 32, 320)	0	conv2d_49[0][0], conv2d_51[0][0], conv2d_53[0][0], conv2d_54[0][0]
conv2d_transpose_5 (Conv2DTranspose)	(None, 64, 64, 128)	163,968	concatenate_10[0…
concatenate_11 (Concatenate)	(None, 64, 64, 448)	0	conv2d_transpose… concatenate_6[0]…
conv2d_56 (Conv2D)	(None, 64, 64, 64)	28,736	concatenate_11[0…
conv2d_58 (Conv2D)	(None, 64, 64, 32)	14,368	concatenate_11[0…
max_pooling2d_14 (MaxPooling2D)	(None, 64, 64, 448)	0	concatenate_11[0…
conv2d_55 (Conv2D)	(None, 64, 64, 32)	14,368	concatenate_11[0…
conv2d_57 (Conv2D)	(None, 64, 64, 64)	36,928	conv2d_56[0][0]
conv2d_59 (Conv2D)	(None, 64, 64, 32)	25,632	conv2d_58[0][0]
conv2d_60 (Conv2D)	(None, 64, 64, 32)	14,368	max_pooling2d_14…
concatenate_12 (Concatenate)	(None, 64, 64, 160)	0	conv2d_55[0][0], conv2d_57[0][0], conv2d_59[0][0], conv2d_60[0][0]
conv2d_transpose_6 (Conv2DTranspose)	(None, 128, 128, 64)	41,024	concatenate_12[0…

concatenate_13 (Concatenate)	(None, 128, 128, 224)	0	conv2d_transpose… concatenate_5[0]…
conv2d_62 (Conv2D)	(None, 128, 128, 32)	7,200	concatenate_13[0…
conv2d_64 (Conv2D)	(None, 128, 128, 16)	3,600	concatenate_13[0…
max_pooling2d_15 (MaxPooling2D)	(None, 128, 128, 224)	0	concatenate_13[0…
conv2d_61 (Conv2D)	(None, 128, 128, 16)	3,600	concatenate_13[0…
conv2d_63 (Conv2D)	(None, 128, 128, 32)	9,248	conv2d_62[0][0]
conv2d_65 (Conv2D)	(None, 128, 128, 16)	6,416	conv2d_64[0][0]
conv2d_66 (Conv2D)	(None, 128, 128, 16)	3,600	max_pooling2d_15…
concatenate_14 (Concatenate)	(None, 128, 128, 80)	0	conv2d_61[0][0], conv2d_63[0][0], conv2d_65[0][0], conv2d_66[0][0]
conv2d_transpose_7 (Conv2DTranspose)	(None, 256, 256, 32)	10,272	concatenate_14[0…
concatenate_15 (Concatenate)	(None, 256, 256, 112)	0	conv2d_transpose… concatenate_4[0]…
conv2d_68 (Conv2D)	(None, 256, 256, 16)	1,808	concatenate_15[0…
conv2d_70 (Conv2D)	(None, 256, 256, 8)	904	concatenate_15[0…
max_pooling2d_16 (MaxPooling2D)	(None, 256, 256, 112)	0	concatenate_15[0…
conv2d_67 (Conv2D)	(None, 256, 256, 8)	904	concatenate_15[0…
conv2d_69 (Conv2D)	(None, 256, 256, 16)	2,320	conv2d_68[0][0]

conv2d_71 (Conv2D)	(None, 256, 256, 8)	1,608	conv2d_70[0][0]
conv2d_72 (Conv2D)	(None, 256, 256, 8)	904	max_pooling2d_16…
concatenate_16 (Concatenate)	(None, 256, 256, 40)	0	conv2d_67[0][0], conv2d_69[0][0], conv2d_71[0][0], conv2d_72[0][0]
conv2d_73 (Conv2D)	(None, 256, 256, 1)	41	concatenate_16[0…

Total params: 13,778,189 (52.56 MB)

Trainable params: 4,592,729 (17.52 MB)

Non-trainable params: 0 (0.00 B)

Optimizer params: 9,185,460 (35.04 MB)

```
plot_model(model, to_file='model_inception.png', show_shapes=True,
show_layer_names=True)
```