

```

...:
...: results = model.fit(X_train, y_train, batch_size=32, epochs=100, callbacks=callbacks,
...:                     validation_data=(X_valid, y_valid))

```

Layer (type)	Output Shape	Param #	Connected to
img (InputLayer)	(None, 512, 512, 1)	0	
conv2d_96 (Conv2D)	(None, 512, 512, 16)	160	img[0][0]
batch_normalization_91 (Batch Normalization)	(None, 512, 512, 16)	64	conv2d_96[0][0]
activation_91 (Activation)	(None, 512, 512, 16)	0	batch_normalization_91[0][0]
conv2d_97 (Conv2D)	(None, 512, 512, 16)	2320	activation_91[0][0]
batch_normalization_92 (Batch Normalization)	(None, 512, 512, 16)	64	conv2d_97[0][0]
activation_92 (Activation)	(None, 512, 512, 16)	0	batch_normalization_92[0][0]
max_pooling2d_21 (MaxPooling2D)	(None, 256, 256, 16)	0	activation_92[0][0]
dropout_41 (Dropout)	(None, 256, 256, 16)	0	max_pooling2d_21[0][0]
conv2d_98 (Conv2D)	(None, 256, 256, 32)	4640	dropout_41[0][0]
batch_normalization_93 (Batch Normalization)	(None, 256, 256, 32)	128	conv2d_98[0][0]
activation_93 (Activation)	(None, 256, 256, 32)	0	batch_normalization_93[0][0]
conv2d_99 (Conv2D)	(None, 256, 256, 32)	9248	activation_93[0][0]
batch_normalization_94 (Batch Normalization)	(None, 256, 256, 32)	128	conv2d_99[0][0]
activation_94 (Activation)	(None, 256, 256, 32)	0	batch_normalization_94[0][0]
max_pooling2d_22 (MaxPooling2D)	(None, 128, 128, 32)	0	activation_94[0][0]
dropout_42 (Dropout)	(None, 128, 128, 32)	0	max_pooling2d_22[0][0]
conv2d_100 (Conv2D)	(None, 128, 128, 64)	18496	dropout_42[0][0]
batch_normalization_95 (Batch Normalization)	(None, 128, 128, 64)	256	conv2d_100[0][0]
activation_95 (Activation)	(None, 128, 128, 64)	0	batch_normalization_95[0][0]
conv2d_101 (Conv2D)	(None, 128, 128, 64)	36928	activation_95[0][0]
batch_normalization_96 (Batch Normalization)	(None, 128, 128, 64)	256	conv2d_101[0][0]
activation_96 (Activation)	(None, 128, 128, 64)	0	batch_normalization_96[0][0]
max_pooling2d_23 (MaxPooling2D)	(None, 64, 64, 64)	0	activation_96[0][0]
dropout_43 (Dropout)	(None, 64, 64, 64)	0	max_pooling2d_23[0][0]
conv2d_102 (Conv2D)	(None, 64, 64, 128)	73856	dropout_43[0][0]
batch_normalization_97 (Batch Normalization)	(None, 64, 64, 128)	512	conv2d_102[0][0]
activation_97 (Activation)	(None, 64, 64, 128)	0	batch_normalization_97[0][0]
conv2d_103 (Conv2D)	(None, 64, 64, 128)	147584	activation_97[0][0]

batch_normalization_98 (BatchNo	(None, 64, 64, 128)	512	conv2d_103[0][0]
activation_98 (Activation)	(None, 64, 64, 128)	0	batch_normalization_98[0][0]
max_pooling2d_24 (MaxPooling2D)	(None, 32, 32, 128)	0	activation_98[0][0]
dropout_44 (Dropout)	(None, 32, 32, 128)	0	max_pooling2d_24[0][0]
conv2d_104 (Conv2D)	(None, 32, 32, 256)	295168	dropout_44[0][0]
batch_normalization_99 (BatchNo	(None, 32, 32, 256)	1024	conv2d_104[0][0]
activation_99 (Activation)	(None, 32, 32, 256)	0	batch_normalization_99[0][0]
conv2d_105 (Conv2D)	(None, 32, 32, 256)	590080	activation_99[0][0]
batch_normalization_100 (BatchN	(None, 32, 32, 256)	1024	conv2d_105[0][0]
activation_100 (Activation)	(None, 32, 32, 256)	0	batch_normalization_100[0][0]
conv2d_transpose_21 (Conv2DTran	(None, 64, 64, 128)	295040	activation_100[0][0]
concatenate_21 (Concatenate)	(None, 64, 64, 256)	0	conv2d_transpose_21[0][0] activation_98[0][0]
dropout_45 (Dropout)	(None, 64, 64, 256)	0	concatenate_21[0][0]
conv2d_106 (Conv2D)	(None, 64, 64, 128)	295040	dropout_45[0][0]
batch_normalization_101 (BatchN	(None, 64, 64, 128)	512	conv2d_106[0][0]
activation_101 (Activation)	(None, 64, 64, 128)	0	batch_normalization_101[0][0]
conv2d_107 (Conv2D)	(None, 64, 64, 128)	147584	activation_101[0][0]
batch_normalization_102 (BatchN	(None, 64, 64, 128)	512	conv2d_107[0][0]
activation_102 (Activation)	(None, 64, 64, 128)	0	batch_normalization_102[0][0]
conv2d_transpose_22 (Conv2DTran	(None, 128, 128, 64)	73792	activation_102[0][0]
concatenate_22 (Concatenate)	(None, 128, 128, 128)	0	conv2d_transpose_22[0][0] activation_96[0][0]
dropout_46 (Dropout)	(None, 128, 128, 128)	0	concatenate_22[0][0]
conv2d_108 (Conv2D)	(None, 128, 128, 64)	73792	dropout_46[0][0]
batch_normalization_103 (BatchN	(None, 128, 128, 64)	256	conv2d_108[0][0]
activation_103 (Activation)	(None, 128, 128, 64)	0	batch_normalization_103[0][0]
conv2d_109 (Conv2D)	(None, 128, 128, 64)	36928	activation_103[0][0]
batch_normalization_104 (BatchN	(None, 128, 128, 64)	256	conv2d_109[0][0]
activation_104 (Activation)	(None, 128, 128, 64)	0	batch_normalization_104[0][0]
conv2d_transpose_23 (Conv2DTran	(None, 256, 256, 32)	18464	activation_104[0][0]
concatenate_23 (Concatenate)	(None, 256, 256, 64)	0	conv2d_transpose_23[0][0] activation_94[0][0]
dropout_47 (Dropout)	(None, 256, 256, 64)	0	concatenate_23[0][0]

conv2d_110 (Conv2D)	(None, 256, 256, 32) 18464	dropout_47[0][0]
batch_normalization_105 (Batch Normalization)	(None, 256, 256, 32) 128	conv2d_110[0][0]
activation_105 (Activation)	(None, 256, 256, 32) 0	batch_normalization_105[0][0]
conv2d_111 (Conv2D)	(None, 256, 256, 32) 9248	activation_105[0][0]
batch_normalization_106 (Batch Normalization)	(None, 256, 256, 32) 128	conv2d_111[0][0]
activation_106 (Activation)	(None, 256, 256, 32) 0	batch_normalization_106[0][0]
conv2d_transpose_24 (Conv2DTranspose)	(None, 512, 512, 16) 4624	activation_106[0][0]
concatenate_24 (Concatenate)	(None, 512, 512, 32) 0	conv2d_transpose_24[0][0] activation_92[0][0]
dropout_48 (Dropout)	(None, 512, 512, 32) 0	concatenate_24[0][0]
conv2d_112 (Conv2D)	(None, 512, 512, 16) 4624	dropout_48[0][0]
batch_normalization_107 (Batch Normalization)	(None, 512, 512, 16) 64	conv2d_112[0][0]
activation_107 (Activation)	(None, 512, 512, 16) 0	batch_normalization_107[0][0]
conv2d_113 (Conv2D)	(None, 512, 512, 16) 2320	activation_107[0][0]
batch_normalization_108 (Batch Normalization)	(None, 512, 512, 16) 64	conv2d_113[0][0]
activation_108 (Activation)	(None, 512, 512, 16) 0	batch_normalization_108[0][0]
conv2d_114 (Conv2D)	(None, 512, 512, 1) 17	activation_108[0][0]

=====

Total params: 2,164,305

Trainable params: 2,161,361

Non-trainable params: 2,944

Train on 4772 samples, validate on 843 samples

Epoch 1/100

Traceback (most recent call last):

```
File "<ipython-input-24-cb6110731226>", line 27, in <module>
    validation_data=(X_valid, y_valid))
```

```
File "C:\Users\tensor19\Anaconda3\envs\kids\lib\site-packages\keras\engine\training.py", line
1039, in fit
    validation_steps=validation_steps)
```

```
File "C:\Users\tensor19\Anaconda3\envs\kids\lib\site-packages\keras\engine\training_arrays.py",
line 199, in fit_loop
    outs = f(ins_batch)
```

```
File "C:\Users\tensor19\Anaconda3\envs\kids\lib\site-
packages\keras\backend\tensorflow_backend.py", line 2715, in __call__
    return self._call(inputs)
```

```
File "C:\Users\tensor19\Anaconda3\envs\kids\lib\site-
packages\keras\backend\tensorflow_backend.py", line 2675, in _call
    fetched = self._callable_fn(*array_vals)
```

```
File "C:\Users\tensor19\Anaconda3\envs\kids\lib\site-
packages\tensorflow\python\client\session.py", line 1439, in __call__
    run_metadata_ptr)
```

KeyboardInterrupt



```

....: c2 = conv2d_block(p1, n_filters=n_filters*2, kernel_size=3, batchnorm=batchnorm)
....: p2 = MaxPooling2D((2, 2)) (c2)
....: p2 = Dropout(dropout)(p2)
....:
....: c3 = conv2d_block(p2, n_filters=n_filters*4, kernel_size=3, batchnorm=batchnorm)
....: p3 = MaxPooling2D((2, 2)) (c3)
....: p3 = Dropout(dropout)(p3)
....:
....: c4 = conv2d_block(p3, n_filters=n_filters*8, kernel_size=3, batchnorm=batchnorm)
....: p4 = MaxPooling2D(pool_size=(2, 2)) (c4)
....: p4 = Dropout(dropout)(p4)
....:
....: c5 = conv2d_block(p4, n_filters=n_filters*16, kernel_size=3, batchnorm=batchnorm)
....:
....: # expansive path
....: u6 = Conv2DTranspose(n_filters*8, (3, 3), strides=(2, 2), padding='same') (c5)
....: u6 = concatenate([u6, c4])
....: u6 = Dropout(dropout)(u6)
....: c6 = conv2d_block(u6, n_filters=n_filters*8, kernel_size=3, batchnorm=batchnorm)
....:
....: u7 = Conv2DTranspose(n_filters*4, (3, 3), strides=(2, 2), padding='same') (c6)
....: u7 = concatenate([u7, c3])
....: u7 = Dropout(dropout)(u7)
....: c7 = conv2d_block(u7, n_filters=n_filters*4, kernel_size=3, batchnorm=batchnorm)
....:
....: u8 = Conv2DTranspose(n_filters*2, (3, 3), strides=(2, 2), padding='same') (c7)
....: u8 = concatenate([u8, c2])
....: u8 = Dropout(dropout)(u8)
....: c8 = conv2d_block(u8, n_filters=n_filters*2, kernel_size=3, batchnorm=batchnorm)
....:
....: u9 = Conv2DTranspose(n_filters*1, (3, 3), strides=(2, 2), padding='same') (c8)
....: u9 = concatenate([u9, c1], axis=3)
....: u9 = Dropout(dropout)(u9)
....: c9 = conv2d_block(u9, n_filters=n_filters*1, kernel_size=3, batchnorm=batchnorm)
....:
....: outputs = Conv2D(1, (1, 1), activation='sigmoid') (c9)
....: model = Model(inputs=[input_img], outputs=[outputs])
....: return model
....:
....:
....:
....: im_width = 512
....: im_height = 512
....:
....:
....:
....: input_img = Input((im_height, im_width, 1), name='img')
....: model = get_unet(input_img, n_filters=16, dropout=0.05, batchnorm=True)
....:
....: model.compile(optimizer=Adam(), loss="binary_crossentropy", metrics=["accuracy"])
....: model.summary()
....:
....:
....:
....: callbacks = [
....:     EarlyStopping(patience=5, verbose=1),
....:     ReduceLROnPlateau(factor=0.1, patience=3, min_lr=0.00001, verbose=1),
....:     ModelCheckpoint('kits_model.h5', verbose=1, save_best_only=True,
save_weights_only=True)
....: ]
....:
....:

```

```

...:
...:
...:
...: results = model.fit(X_train, y_train, batch_size=32, epochs=100, callbacks=callbacks,
...:                     validation_data=(X_valid, y_valid))

```

Layer (type)	Output Shape	Param #	Connected to
img (InputLayer)	(None, 512, 512, 1)	0	
conv2d_115 (Conv2D)	(None, 512, 512, 16)	160	img[0][0]
batch_normalization_109 (Batch Normalization)	(None, 512, 512, 16)	64	conv2d_115[0][0]
activation_109 (Activation)	(None, 512, 512, 16)	0	batch_normalization_109[0][0]
conv2d_116 (Conv2D)	(None, 512, 512, 16)	2320	activation_109[0][0]
batch_normalization_110 (Batch Normalization)	(None, 512, 512, 16)	64	conv2d_116[0][0]
activation_110 (Activation)	(None, 512, 512, 16)	0	batch_normalization_110[0][0]
max_pooling2d_25 (MaxPooling2D)	(None, 256, 256, 16)	0	activation_110[0][0]
dropout_49 (Dropout)	(None, 256, 256, 16)	0	max_pooling2d_25[0][0]
conv2d_117 (Conv2D)	(None, 256, 256, 32)	4640	dropout_49[0][0]
batch_normalization_111 (Batch Normalization)	(None, 256, 256, 32)	128	conv2d_117[0][0]
activation_111 (Activation)	(None, 256, 256, 32)	0	batch_normalization_111[0][0]
conv2d_118 (Conv2D)	(None, 256, 256, 32)	9248	activation_111[0][0]
batch_normalization_112 (Batch Normalization)	(None, 256, 256, 32)	128	conv2d_118[0][0]
activation_112 (Activation)	(None, 256, 256, 32)	0	batch_normalization_112[0][0]
max_pooling2d_26 (MaxPooling2D)	(None, 128, 128, 32)	0	activation_112[0][0]
dropout_50 (Dropout)	(None, 128, 128, 32)	0	max_pooling2d_26[0][0]
conv2d_119 (Conv2D)	(None, 128, 128, 64)	18496	dropout_50[0][0]
batch_normalization_113 (Batch Normalization)	(None, 128, 128, 64)	256	conv2d_119[0][0]
activation_113 (Activation)	(None, 128, 128, 64)	0	batch_normalization_113[0][0]
conv2d_120 (Conv2D)	(None, 128, 128, 64)	36928	activation_113[0][0]
batch_normalization_114 (Batch Normalization)	(None, 128, 128, 64)	256	conv2d_120[0][0]
activation_114 (Activation)	(None, 128, 128, 64)	0	batch_normalization_114[0][0]
max_pooling2d_27 (MaxPooling2D)	(None, 64, 64, 64)	0	activation_114[0][0]
dropout_51 (Dropout)	(None, 64, 64, 64)	0	max_pooling2d_27[0][0]
conv2d_121 (Conv2D)	(None, 64, 64, 128)	73856	dropout_51[0][0]
batch_normalization_115 (Batch Normalization)	(None, 64, 64, 128)	512	conv2d_121[0][0]
activation_115 (Activation)	(None, 64, 64, 128)	0	batch_normalization_115[0][0]
conv2d_122 (Conv2D)	(None, 64, 64, 128)	147584	activation_115[0][0]

batch_normalization_116 (BatchN	(None, 64, 64, 128)	512	conv2d_122[0][0]
activation_116 (Activation)	(None, 64, 64, 128)	0	batch_normalization_116[0][0]
max_pooling2d_28 (MaxPooling2D)	(None, 32, 32, 128)	0	activation_116[0][0]
dropout_52 (Dropout)	(None, 32, 32, 128)	0	max_pooling2d_28[0][0]
conv2d_123 (Conv2D)	(None, 32, 32, 256)	295168	dropout_52[0][0]
batch_normalization_117 (BatchN	(None, 32, 32, 256)	1024	conv2d_123[0][0]
activation_117 (Activation)	(None, 32, 32, 256)	0	batch_normalization_117[0][0]
conv2d_124 (Conv2D)	(None, 32, 32, 256)	590080	activation_117[0][0]
batch_normalization_118 (BatchN	(None, 32, 32, 256)	1024	conv2d_124[0][0]
activation_118 (Activation)	(None, 32, 32, 256)	0	batch_normalization_118[0][0]
conv2d_transpose_25 (Conv2DTran	(None, 64, 64, 128)	295040	activation_118[0][0]
concatenate_25 (Concatenate)	(None, 64, 64, 256)	0	conv2d_transpose_25[0][0] activation_116[0][0]
dropout_53 (Dropout)	(None, 64, 64, 256)	0	concatenate_25[0][0]
conv2d_125 (Conv2D)	(None, 64, 64, 128)	295040	dropout_53[0][0]
batch_normalization_119 (BatchN	(None, 64, 64, 128)	512	conv2d_125[0][0]
activation_119 (Activation)	(None, 64, 64, 128)	0	batch_normalization_119[0][0]
conv2d_126 (Conv2D)	(None, 64, 64, 128)	147584	activation_119[0][0]
batch_normalization_120 (BatchN	(None, 64, 64, 128)	512	conv2d_126[0][0]
activation_120 (Activation)	(None, 64, 64, 128)	0	batch_normalization_120[0][0]
conv2d_transpose_26 (Conv2DTran	(None, 128, 128, 64)	73792	activation_120[0][0]
concatenate_26 (Concatenate)	(None, 128, 128, 128)	0	conv2d_transpose_26[0][0] activation_114[0][0]
dropout_54 (Dropout)	(None, 128, 128, 128)	0	concatenate_26[0][0]
conv2d_127 (Conv2D)	(None, 128, 128, 64)	73792	dropout_54[0][0]
batch_normalization_121 (BatchN	(None, 128, 128, 64)	256	conv2d_127[0][0]
activation_121 (Activation)	(None, 128, 128, 64)	0	batch_normalization_121[0][0]
conv2d_128 (Conv2D)	(None, 128, 128, 64)	36928	activation_121[0][0]
batch_normalization_122 (BatchN	(None, 128, 128, 64)	256	conv2d_128[0][0]
activation_122 (Activation)	(None, 128, 128, 64)	0	batch_normalization_122[0][0]
conv2d_transpose_27 (Conv2DTran	(None, 256, 256, 32)	18464	activation_122[0][0]
concatenate_27 (Concatenate)	(None, 256, 256, 64)	0	conv2d_transpose_27[0][0] activation_112[0][0]
dropout_55 (Dropout)	(None, 256, 256, 64)	0	concatenate_27[0][0]

conv2d_129 (Conv2D)	(None, 256, 256, 32) 18464	dropout_55[0][0]
batch_normalization_123 (Batch Normalization)	(None, 256, 256, 32) 128	conv2d_129[0][0]
activation_123 (Activation)	(None, 256, 256, 32) 0	batch_normalization_123[0][0]
conv2d_130 (Conv2D)	(None, 256, 256, 32) 9248	activation_123[0][0]
batch_normalization_124 (Batch Normalization)	(None, 256, 256, 32) 128	conv2d_130[0][0]
activation_124 (Activation)	(None, 256, 256, 32) 0	batch_normalization_124[0][0]
conv2d_transpose_28 (Conv2DTranspose)	(None, 512, 512, 16) 4624	activation_124[0][0]
concatenate_28 (Concatenate)	(None, 512, 512, 32) 0	conv2d_transpose_28[0][0] activation_110[0][0]
dropout_56 (Dropout)	(None, 512, 512, 32) 0	concatenate_28[0][0]
conv2d_131 (Conv2D)	(None, 512, 512, 16) 4624	dropout_56[0][0]
batch_normalization_125 (Batch Normalization)	(None, 512, 512, 16) 64	conv2d_131[0][0]
activation_125 (Activation)	(None, 512, 512, 16) 0	batch_normalization_125[0][0]
conv2d_132 (Conv2D)	(None, 512, 512, 16) 2320	activation_125[0][0]
batch_normalization_126 (Batch Normalization)	(None, 512, 512, 16) 64	conv2d_132[0][0]
activation_126 (Activation)	(None, 512, 512, 16) 0	batch_normalization_126[0][0]
conv2d_133 (Conv2D)	(None, 512, 512, 1) 17	activation_126[0][0]

=====

Total params: 2,164,305

Trainable params: 2,161,361

Non-trainable params: 2,944

Train on 4492 samples, validate on 1123 samples

Epoch 1/100

4492/4492 [=====] - 8518s 2s/step - loss: 0.2060 - acc: 0.9505 -  
val\_loss: 0.8125 - val\_acc: 0.90349418

Epoch 00001: val\_loss improved from inf to 0.81246, saving model to kits\_model.h5

Epoch 2/100

4492/4492 [=====] - 8486s 2s/step - loss: -0.0543 - acc: 0.9795 -  
val\_loss: -0.0432 - val\_acc: 0.9794

Epoch 00002: val\_loss improved from 0.81246 to -0.04315, saving model to kits\_model.h5

Epoch 3/100

4492/4492 [=====] - 8465s 2s/step - loss: -0.1309 - acc: 0.9828 -  
val\_loss: -0.1471 - val\_acc: 0.9825..] - ETA: 1:12:00 - loss: -0.1154 - acc: 0.98282464/4492  
[=====>.....] - ETA: 57:23 - loss: -0.1205 - acc: 0.9827

Epoch 00003: val\_loss improved from -0.04315 to -0.14710, saving model to kits\_model.h5

Epoch 4/100

4492/4492 [=====] - 8421s 2s/step - loss: -0.1537 - acc: 0.9837 -  
val\_loss: -0.1629 - val\_acc: 0.9829

Epoch 00004: val\_loss improved from -0.14710 to -0.16289, saving model to kits\_model.h5

Epoch 5/100

2336/4492 [=====>.....] - ETA: 1:16:32 - loss: -0.1686 - acc: 0.9842



```
In [3]: Image_data.shape
...: Target_data.shape
Out[3]: (5615, 512, 512, 1)

In [4]: Image_data.shape
Out[4]: (5615, 512, 512, 1)

In [5]: Target_data.shape
Out[5]: (5615, 512, 512, 1)

In [6]: print("Label data : {:.2f}MB \
...:         Image data : {:.2f}MB ".format(Target_data.nbytes / (1024 * 1000.0), Image_data.nbytes / (1024 * 1000.0)))
```

```

...:
...:
...: print(Image_data.shape)
...: print(Target_data.shape)
Label data : 1437.44MB      Image data :11499.52MB
(5615, 512, 512, 1)
(5615, 512, 512, 1)

In [7]: import os
...: import random
...: import pandas as pd
...: import numpy as np
...: import matplotlib.pyplot as plt
...: plt.style.use("ggplot")
...:
...:
...: from tqdm import tqdm_notebook, trange
...: from itertools import chain
...: from skimage.io import imread, imshow, concatenate_images
...: from skimage.transform import resize
...: from skimage.morphology import label
...: from sklearn.model_selection import train_test_split
...:
...: import tensorflow as tf
...:
...: from keras.models import Model, load_model
...: from keras.layers import Input, BatchNormalization, Activation, Dense, Dropout
...: from keras.layers.core import Lambda, RepeatVector, Reshape
...: from keras.layers.convolutional import Conv2D, Conv2DTranspose
...: from keras.layers.pooling import MaxPooling2D, GlobalMaxPool2D
...: from keras.layers.merge import concatenate, add
...: from keras.callbacks import EarlyStopping, ModelCheckpoint, ReduceLROnPlateau
...: from keras.optimizers import Adam
...: from keras.preprocessing.image import ImageDataGenerator, array_to_img, img_to_array, load_img
...:
...:
...: X_train, X_valid, y_train, y_valid = train_test_split(Image_data, Target_data, test_size=0.20, random_state=2018)
Using TensorFlow backend.

In [8]: def conv2d_block(input_tensor, n_filters, kernel_size=3, batchnorm=True):
...:     # first layer
...:     x = Conv2D(filters=n_filters, kernel_size=(kernel_size, kernel_size), kernel_initializer="he_normal",
...:               padding="same")(input_tensor)
...:     if batchnorm:
...:         x = BatchNormalization()(x)
...:     x = Activation("relu")(x)
...:     # second layer
...:     x = Conv2D(filters=n_filters, kernel_size=(kernel_size, kernel_size), kernel_initializer="he_normal",
...:               padding="same")(x)
...:     if batchnorm:
...:         x = BatchNormalization()(x)
...:     x = Activation("relu")(x)
...:     return x
...:
...:
...:
...:
...: def get_unet(input_img, n_filters=16, dropout=0.5, batchnorm=True):
...:     # contracting path
...:     c1 = conv2d_block(input_img, n_filters=n_filters*1, kernel_size=3, batchnorm=batchnorm)
...:     p1 = MaxPooling2D((2, 2))(c1)
...:     p1 = Dropout(dropout*0.5)(p1)
...:
...:     c2 = conv2d_block(p1, n_filters=n_filters*2, kernel_size=3, batchnorm=batchnorm)
...:     p2 = MaxPooling2D((2, 2))(c2)
...:     p2 = Dropout(dropout)(p2)
...:
...:     c3 = conv2d_block(p2, n_filters=n_filters*4, kernel_size=3, batchnorm=batchnorm)
...:     p3 = MaxPooling2D((2, 2))(c3)
...:     p3 = Dropout(dropout)(p3)
...:
...:     c4 = conv2d_block(p3, n_filters=n_filters*8, kernel_size=3, batchnorm=batchnorm)
...:     p4 = MaxPooling2D(pool_size=(2, 2))(c4)
...:     p4 = Dropout(dropout)(p4)
...:
...:     c5 = conv2d_block(p4, n_filters=n_filters*16, kernel_size=3, batchnorm=batchnorm)
...:
...:     # expansive path
...:     u6 = Conv2DTranspose(n_filters*8, (3, 3), strides=(2, 2), padding='same')(c5)
...:     u6 = concatenate([u6, c4])
...:     u6 = Dropout(dropout)(u6)
...:     c6 = conv2d_block(u6, n_filters=n_filters*8, kernel_size=3, batchnorm=batchnorm)
...:
...:     u7 = Conv2DTranspose(n_filters*4, (3, 3), strides=(2, 2), padding='same')(c6)
...:     u7 = concatenate([u7, c3])
...:     u7 = Dropout(dropout)(u7)
...:     c7 = conv2d_block(u7, n_filters=n_filters*4, kernel_size=3, batchnorm=batchnorm)
...:
...:     u8 = Conv2DTranspose(n_filters*2, (3, 3), strides=(2, 2), padding='same')(c7)
...:     u8 = concatenate([u8, c2])
...:     u8 = Dropout(dropout)(u8)
...:     c8 = conv2d_block(u8, n_filters=n_filters*2, kernel_size=3, batchnorm=batchnorm)
...:
...:     u9 = Conv2DTranspose(n_filters*1, (3, 3), strides=(2, 2), padding='same')(c8)
...:     u9 = concatenate([u9, c1], axis=3)
...:     u9 = Dropout(dropout)(u9)
...:     c9 = conv2d_block(u9, n_filters=n_filters*1, kernel_size=3, batchnorm=batchnorm)
...:
...:

```

```

...: outputs = Conv2D(1, (1, 1), activation='sigmoid') (c9)
...: model = Model(inputs=[input_img], outputs=[outputs])
...: return model
...:
...:
...:
...:
...:
...: im_width = 512
...: im_height = 512

```

```

In [9]: input_img = Input((im_height, im_width, 1), name='img')
...: model = get_unet(input_img, n_filters=16, dropout=0.05, batchnorm=True)
...:
...: model.compile(optimizer=Adam(), loss="binary_crossentropy", metrics=["accuracy"])
...: model.summary()

```

WARNING:tensorflow:From C:\Users\tensor19\Anaconda3\envs\kids\lib\site-packages\tensorflow\python\framework\op\_def\_library.py:263: colocate\_with (from tensorflow.python.framework.ops) is deprecated and will be removed in a future version.

Instructions for updating:

Colocations handled automatically by placer.

WARNING:tensorflow:From C:\Users\tensor19\Anaconda3\envs\kids\lib\site-packages\keras\backend\tensorflow\_backend.py:3445: calling dropout (from tensorflow.python.ops.nn\_ops) with keep\_prob is deprecated and will be removed in a future version.

Instructions for updating:

Please use `rate` instead of `keep\_prob`. Rate should be set to `rate = 1 - keep\_prob`.

Layer (type)	Output Shape	Param #	Connected to
img (InputLayer)	(None, 512, 512, 1)	0	
conv2d_1 (Conv2D)	(None, 512, 512, 16)	160	img[0][0]
batch_normalization_1 (BatchNor	(None, 512, 512, 16)	64	conv2d_1[0][0]
activation_1 (Activation)	(None, 512, 512, 16)	0	batch_normalization_1[0][0]
conv2d_2 (Conv2D)	(None, 512, 512, 16)	2320	activation_1[0][0]
batch_normalization_2 (BatchNor	(None, 512, 512, 16)	64	conv2d_2[0][0]
activation_2 (Activation)	(None, 512, 512, 16)	0	batch_normalization_2[0][0]
max_pooling2d_1 (MaxPooling2D)	(None, 256, 256, 16)	0	activation_2[0][0]
dropout_1 (Dropout)	(None, 256, 256, 16)	0	max_pooling2d_1[0][0]
conv2d_3 (Conv2D)	(None, 256, 256, 32)	4640	dropout_1[0][0]
batch_normalization_3 (BatchNor	(None, 256, 256, 32)	128	conv2d_3[0][0]
activation_3 (Activation)	(None, 256, 256, 32)	0	batch_normalization_3[0][0]
conv2d_4 (Conv2D)	(None, 256, 256, 32)	9248	activation_3[0][0]
batch_normalization_4 (BatchNor	(None, 256, 256, 32)	128	conv2d_4[0][0]
activation_4 (Activation)	(None, 256, 256, 32)	0	batch_normalization_4[0][0]
max_pooling2d_2 (MaxPooling2D)	(None, 128, 128, 32)	0	activation_4[0][0]
dropout_2 (Dropout)	(None, 128, 128, 32)	0	max_pooling2d_2[0][0]
conv2d_5 (Conv2D)	(None, 128, 128, 64)	18496	dropout_2[0][0]
batch_normalization_5 (BatchNor	(None, 128, 128, 64)	256	conv2d_5[0][0]
activation_5 (Activation)	(None, 128, 128, 64)	0	batch_normalization_5[0][0]
conv2d_6 (Conv2D)	(None, 128, 128, 64)	36928	activation_5[0][0]
batch_normalization_6 (BatchNor	(None, 128, 128, 64)	256	conv2d_6[0][0]
activation_6 (Activation)	(None, 128, 128, 64)	0	batch_normalization_6[0][0]
max_pooling2d_3 (MaxPooling2D)	(None, 64, 64, 64)	0	activation_6[0][0]
dropout_3 (Dropout)	(None, 64, 64, 64)	0	max_pooling2d_3[0][0]
conv2d_7 (Conv2D)	(None, 64, 64, 128)	73856	dropout_3[0][0]
batch_normalization_7 (BatchNor	(None, 64, 64, 128)	512	conv2d_7[0][0]
activation_7 (Activation)	(None, 64, 64, 128)	0	batch_normalization_7[0][0]
conv2d_8 (Conv2D)	(None, 64, 64, 128)	147584	activation_7[0][0]
batch_normalization_8 (BatchNor	(None, 64, 64, 128)	512	conv2d_8[0][0]
activation_8 (Activation)	(None, 64, 64, 128)	0	batch_normalization_8[0][0]
max_pooling2d_4 (MaxPooling2D)	(None, 32, 32, 128)	0	activation_8[0][0]
dropout_4 (Dropout)	(None, 32, 32, 128)	0	max_pooling2d_4[0][0]
conv2d_9 (Conv2D)	(None, 32, 32, 256)	295168	dropout_4[0][0]
batch_normalization_9 (BatchNor	(None, 32, 32, 256)	1024	conv2d_9[0][0]
activation_9 (Activation)	(None, 32, 32, 256)	0	batch_normalization_9[0][0]

conv2d_10 (Conv2D)	(None, 32, 32, 256)	590080	activation_9[0][0]
batch_normalization_10 (BatchNormalizatio	(None, 32, 32, 256)	1024	conv2d_10[0][0]
activation_10 (Activation)	(None, 32, 32, 256)	0	batch_normalization_10[0][0]
conv2d_transpose_1 (Conv2DTranspose)	(None, 64, 64, 128)	295040	activation_10[0][0]
concatenate_1 (Concatenate)	(None, 64, 64, 256)	0	conv2d_transpose_1[0][0] activation_8[0][0]
dropout_5 (Dropout)	(None, 64, 64, 256)	0	concatenate_1[0][0]
conv2d_11 (Conv2D)	(None, 64, 64, 128)	295040	dropout_5[0][0]
batch_normalization_11 (BatchNormalizatio	(None, 64, 64, 128)	512	conv2d_11[0][0]
activation_11 (Activation)	(None, 64, 64, 128)	0	batch_normalization_11[0][0]
conv2d_12 (Conv2D)	(None, 64, 64, 128)	147584	activation_11[0][0]
batch_normalization_12 (BatchNormalizatio	(None, 64, 64, 128)	512	conv2d_12[0][0]
activation_12 (Activation)	(None, 64, 64, 128)	0	batch_normalization_12[0][0]
conv2d_transpose_2 (Conv2DTranspose)	(None, 128, 128, 64)	73792	activation_12[0][0]
concatenate_2 (Concatenate)	(None, 128, 128, 128)	0	conv2d_transpose_2[0][0] activation_6[0][0]
dropout_6 (Dropout)	(None, 128, 128, 128)	0	concatenate_2[0][0]
conv2d_13 (Conv2D)	(None, 128, 128, 64)	73792	dropout_6[0][0]
batch_normalization_13 (BatchNormalizatio	(None, 128, 128, 64)	256	conv2d_13[0][0]
activation_13 (Activation)	(None, 128, 128, 64)	0	batch_normalization_13[0][0]
conv2d_14 (Conv2D)	(None, 128, 128, 64)	36928	activation_13[0][0]
batch_normalization_14 (BatchNormalizatio	(None, 128, 128, 64)	256	conv2d_14[0][0]
activation_14 (Activation)	(None, 128, 128, 64)	0	batch_normalization_14[0][0]
conv2d_transpose_3 (Conv2DTranspose)	(None, 256, 256, 32)	18464	activation_14[0][0]
concatenate_3 (Concatenate)	(None, 256, 256, 64)	0	conv2d_transpose_3[0][0] activation_4[0][0]
dropout_7 (Dropout)	(None, 256, 256, 64)	0	concatenate_3[0][0]
conv2d_15 (Conv2D)	(None, 256, 256, 32)	18464	dropout_7[0][0]
batch_normalization_15 (BatchNormalizatio	(None, 256, 256, 32)	128	conv2d_15[0][0]
activation_15 (Activation)	(None, 256, 256, 32)	0	batch_normalization_15[0][0]
conv2d_16 (Conv2D)	(None, 256, 256, 32)	9248	activation_15[0][0]
batch_normalization_16 (BatchNormalizatio	(None, 256, 256, 32)	128	conv2d_16[0][0]
activation_16 (Activation)	(None, 256, 256, 32)	0	batch_normalization_16[0][0]
conv2d_transpose_4 (Conv2DTranspose)	(None, 512, 512, 16)	4624	activation_16[0][0]
concatenate_4 (Concatenate)	(None, 512, 512, 32)	0	conv2d_transpose_4[0][0] activation_2[0][0]
dropout_8 (Dropout)	(None, 512, 512, 32)	0	concatenate_4[0][0]
conv2d_17 (Conv2D)	(None, 512, 512, 16)	4624	dropout_8[0][0]
batch_normalization_17 (BatchNormalizatio	(None, 512, 512, 16)	64	conv2d_17[0][0]
activation_17 (Activation)	(None, 512, 512, 16)	0	batch_normalization_17[0][0]
conv2d_18 (Conv2D)	(None, 512, 512, 16)	2320	activation_17[0][0]
batch_normalization_18 (BatchNormalizatio	(None, 512, 512, 16)	64	conv2d_18[0][0]
activation_18 (Activation)	(None, 512, 512, 16)	0	batch_normalization_18[0][0]
conv2d_19 (Conv2D)	(None, 512, 512, 1)	17	activation_18[0][0]
=====			
Total params: 2,164,305			
Trainable params: 2,161,361			
Non-trainable params: 2,944			

```
In [10]: callbacks = [
...:     EarlyStopping(patience=5, verbose=1),
...:     ReduceLROnPlateau(factor=0.1, patience=3, min_lr=0.00001, verbose=1),
...:     ModelCheckpoint('kits_model.h5', verbose=1, save_best_only=True, save_weights_only=True)
...: ]
```

```
In [11]: plt.figure(figsize=(8, 8))
...: plt.title("Learning curve")
...: plt.plot(results.history["loss"], label="loss")
```

```

...: plt.plot(results.history["val_loss"], label="val_loss")
...: plt.plot( np.argmin(results.history["val_loss"]), np.min(results.history["val_loss"]), marker="x", color="r", label="best model")
...: plt.xlabel("Epochs")
...: plt.ylabel("log_loss")
...: plt.legend();

```

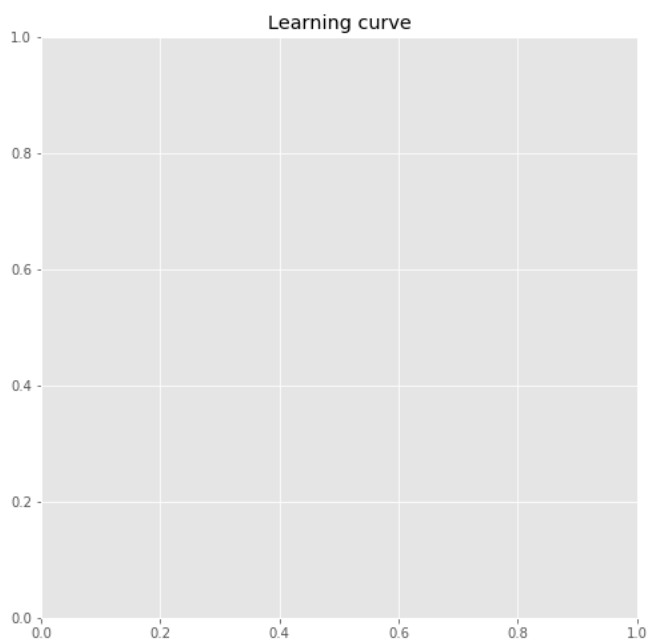
Traceback (most recent call last):

```

File "<ipython-input-11-6a34272a34c5>", line 3, in <module>
    plt.plot(results.history["loss"], label="loss")

```

**NameError:** name 'results' is not defined



In [12]:

In [12]: model.load\_weights('kits\_model.h5')

In [13]: model.evaluate(X\_valid, y\_valid, verbose=1)

```

...:
...: # Predict on train, val and test
...: preds_train = model.predict(X_train, verbose=1)
...: preds_val = model.predict(X_valid, verbose=1)
...:
...: # Threshold predictions
...: preds_train_t = (preds_train > 0.5).astype(np.uint8)
...: preds_val_t = (preds_val > 0.5).astype(np.uint8)
1123/1123 [=====] - 837s 745ms/step
4492/4492 [=====] - 3381s 753ms/step492 [====>.....] - ETA: 46:21 - ETA: 38:31
1123/1123 [=====] - 846s 753ms/stepA: 7:17

```

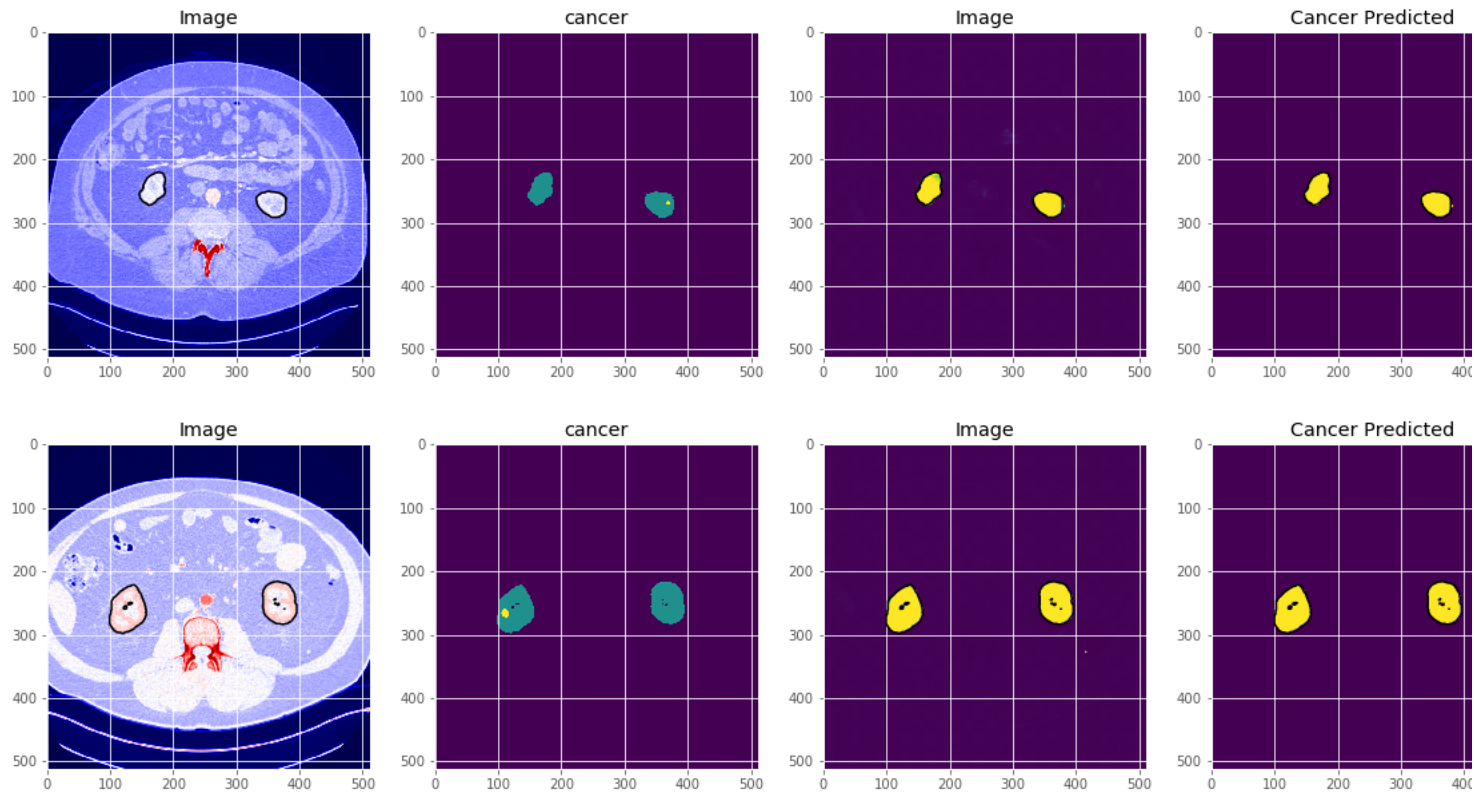
In [14]: preds\_train\_t = (preds\_train > 0.5).astype(np.uint8)  
...: preds\_val\_t = (preds\_val > 0.5).astype(np.uint8)

```

In [15]: def plot_sample(X, y, preds, binary_preds, ix=None):
...:     if ix is None:
...:         ix = random.randint(0, len(X))
...:
...:     has_mask = y[ix].max() > 0
...:
...:     fig, ax = plt.subplots(1, 4, figsize=(20, 10))
...:
...:     ax[0].imshow(X[ix, ..., 0], cmap='seismic')
...:     if has_mask:
...:         ax[0].contour(y[ix].squeeze(), colors='k', levels=[0.5])
...:     ax[0].set_title('Seismic')
...:
...:     ax[1].imshow(y[ix].squeeze())
...:     ax[1].set_title('Salt')
...:
...:     ax[2].imshow(preds[ix].squeeze(), vmin=0, vmax=1)
...:     if has_mask:
...:         ax[2].contour(y[ix].squeeze(), colors='k', levels=[0.5])
...:     ax[2].set_title('Salt Predicted')
...:
...:     ax[3].imshow(binary_preds[ix].squeeze(), vmin=0, vmax=1)
...:     if has_mask:
...:         ax[3].contour(y[ix].squeeze(), colors='k', levels=[0.5])
...:     ax[3].set_title('Salt Predicted binary');

```

In [16]: plot\_sample(X\_train, y\_train, preds\_train, preds\_train\_t, ix=14)



In [19]: