```
!pip install ipython-autotime
!apt-get install openslide-tools
!pip install openslide-python
%load_ext autotime
```

```
  Downloading https://files.pythonhosted.org/packages/b4/c9/b413a24f759641bc27ef
Requirement already satisfied: ipython in /usr/local/lib/python3.7/dist-packages
Requirement already satisfied: traitlets>=4.2 in /usr/local/lib/python3.7/dist-p
Requirement already satisfied: setuptools>=18.5 in /usr/local/lib/python3.7/dist
Requirement already satisfied: pickleshare in /usr/local/lib/python3.7/dist-pack
Requirement already satisfied: pexpect; sys_platform != "win32" in /usr/local/li
Requirement already satisfied: prompt-toolkit<2.0.0,>=1.0.4 in /usr/local/lib/py
Requirement already satisfied: decorator in /usr/local/lib/python3.7/dist-packag
Requirement already satisfied: pygments in /usr/local/lib/python3.7/dist-package
Requirement already satisfied: simplegeneric>0.8 in /usr/local/lib/python3.7/dis
Requirement already satisfied: ipython-genutils in /usr/local/lib/python3.7/dist
Requirement already satisfied: ptyprocess>=0.5 in /usr/local/lib/python3.7/dist-
Requirement already satisfied: wcwidth in /usr/local/lib/python3.7/dist-packages
Requirement already satisfied: six>=1.9.0 in /usr/local/lib/python3.7/dist-packa
Installing collected packages: ipython-autotime
Successfully installed ipython-autotime-0.3.1
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following package was automatically installed and is no longer required:
  libnvidia-common-460
Use 'apt autoremove' to remove it.
The following additional packages will be installed:
  libopenslide0
Suggested packages:
  libtiff-tools
The following NEW packages will be installed:
  libopenslide0 openslide-tools
0 upgraded, 2 newly installed, 0 to remove and 34 not upgraded.
Need to get 92.5 kB of archives.
After this operation, 268 kB of additional disk space will be used.
Get:1 http://archive.ubuntu.com/ubuntu bionic/universe amd64 libopenslide0 amd64
Get:2 http://archive.ubuntu.com/ubuntu bionic/universe amd64 openslide-tools amd
Fetched 92.5 kB in 1s (149 kB/s)
Selecting previously unselected package libopenslide0.
(Reading database ... 160690 files and directories currently installed.)
Preparing to unpack .../libopenslide0_3.4.1+dfsg-2_amd64.deb ...
Unpacking libopenslide0 (3.4.1+dfsg-2) ...
Selecting previously unselected package openslide-tools.
Preparing to unpack .../openslide-tools_3.4.1+dfsg-2_amd64.deb ...
Unpacking openslide-tools (3.4.1+dfsg-2) ...
Setting up libopenslide0 (3.4.1+dfsg-2) ...
Setting up openslide-tools (3.4.1+dfsg-2) ...
Processing triggers for libc-bin (2.27-3ubuntu1.2) ...
/sbin/ldconfig.real: /usr/local/lib/python3.7/dist-packages/ideep4py/lib/libmkld

Processing triggers for man-db (2.8.3-2ubuntu0.1) ...
Collecting openslide-python
  Downloading https://files.pythonhosted.org/packages/03/da/12dc0e7566ace61a5a65
     |████████████████████████████████| 317kB 6.6MB/s
```

```
Requirement already satisfied: Pillow in /usr/local/lib/python3.7/dist-packages
Building wheels for collected packages: openslide-python
  Building wheel for openslide-python (setup.py) ... done
  Created wheel for openslide-python: filename=openslide_python-1.1.2-cp37-cp37m
  Stored in directory: /root/.cache/pip/wheels/6b/55/74/ba9d3dcc2c5c0f1282e08bae
Successfully built openslide-python
Installing collected packages: openslide-python
Successfully installed openslide-python-1.1.2
time: 3.5 ms (started: 2021-04-29 14:38:17 +00:00)
```

```
%matplotlib inline
import matplotlib.pyplot as plt
import matplotlib.image as mpimg
from openslide import open_slide, __library_version__ as openslide_versi
import seaborn as sns; sns.set_theme()
from sklearn.model_selection import train_test_split
import numpy as np
import pickle
import os
from PIL import Image
```

```
time: 866 ms (started: 2021-04-29 14:38:22 +00:00)
```

```
import tensorflow as tf
from tensorflow import keras
from tensorflow.keras import layers, models
from tensorflow.keras.layers import Conv2D, MaxPooling2D, Flatten
from tensorflow.keras.layers import Input, LSTM, Embedding, Dense, Globa
from tensorflow.keras.models import Model, Sequential
tf.__version__
```

```
'2.4.1'  time: 14.6 ms (started: 2021-04-29 14:49:04 +00:00)
```

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

```
Mounted at /content/drive/
time: 15.1 s (started: 2021-04-29 14:38:33 +00:00)
```

Inception Model with Data Augmentation

```
PATCH_SIZE = 75 # size of the patches
LEVEL = 4
LEVEL_1 = 4 # first zoom level
LEVEL_2 = 3 # second zoom level
```

```
dataset_path = "/content/drive/MyDrive/Columbia_Assignments/ADL/Project/

train_file_normal = os.path.join(dataset_path, 'train/camelyon_preproces
train_file_zoomed = os.path.join(dataset_path, 'train/camelyon_preproces

test_file_normal = os.path.join(dataset_path, 'test/camelyon_preprocesse
test_file_zoomed = os.path.join(dataset_path, 'test/camelyon_preprocesse
```

```
time: 9.71 ms (started: 2021-04-29 14:43:11 +00:00)
```

Load train and test dataset

Load the data from the pickle file uploaded to the drive.

```
def load_dataset(file_path):
    with open(file_path, 'rb') as f:
        slides, labels = pickle.load(f)
    return slides, labels
```

```
time: 2.54 ms (started: 2021-04-29 14:40:29 +00:00)
```

```
# load the training dataset and labels

train_slides, train_labels = load_dataset(train_file_normal)
train_slides = np.array(train_slides)
train_labels = np.array(train_labels)
print("Training slides length: {}".format(len(train_slides)))
print("Train labels: {}".format(train_labels))
print("Number of cancerous labels: {}".format(np.sum(train_labels)))
```

```
Training slides length: 30065
Train labels: [0 0 0 ... 0 0 0]
Number of cancerous labels: 2016
time: 9.98 s (started: 2021-04-29 17:27:51 +00:00)
```

```
# load the zoomed training dataset and labels

train_zoomed_slides, train_labels = load_dataset(train_file_zoomed)
train_zoomed_slides = np.array(train_zoomed_slides)
train_labels = np.array(train_labels)
print("Training slides length: {}".format(len(train_zoomed_slides)))
print("Train labels: {}".format(train_labels))
print("Number of cancerous labels: {}".format(np.sum(train_labels)))
```

```
Training slides length: 30065
Train labels: [0 0 0 ... 0 0 0]
```

```
Number of cancerous labels: 2016
time: 3.47 s (started: 2021-04-29 16:36:10 +00:00)
```

```
# load the test dataset and labels

test_slides, test_labels = load_dataset(test_file_normal)
test_slides = np.array(test_slides)
test_labels = np.array(test_labels)
print("Test slides length: {}".format(len(test_slides)))
print("Test labels: {}".format(test_labels))
print("Number of cancerous labels: {}".format(np.sum(test_labels)))
```

```
Test slides length: 11446
Test labels: [0 0 0 ... 0 0 0]
Number of cancerous labels: 1149
time: 4.63 s (started: 2021-04-29 14:43:15 +00:00)
```

```
# load the zoomed test dataset and labels

test_zoomed_slides, test_labels = load_dataset(test_file_zoomed)
test_zoomed_slides = np.array(test_zoomed_slides)
test_labels = np.array(test_labels)
print("Test slides length: {}".format(len(test_zoomed_slides)))
print("Test labels: {}".format(test_labels))
print("Number of cancerous labels: {}".format(np.sum(test_labels)))
```

```
Test slides length: 11446
Test labels: [0 0 0 ... 0 0 0]
Number of cancerous labels: 1149
time: 2.72 s (started: 2021-04-29 16:40:16 +00:00)
```

Split the training dataset into validation

```
rain_slides, val_slides, train_zoomed_slides, val_zoomed_slides, train_
rint("Validation slides length: {}".format(len(val_slides)))
rint("Validation zoomed slides length: {}".format(len(val_zoomed_slides
rint("Validation labels: {}".format(val_labels))
rint("Number of cancerous labels: {}".format(np.sum(val_labels)))
```

```
Validation slides length: 7517
Validation zoomed slides length: 7517
Validation labels: [1 0 0 ... 0 0 0]
Number of cancerous labels: 494
time: 1.02 s (started: 2021-04-29 14:46:23 +00:00)
```

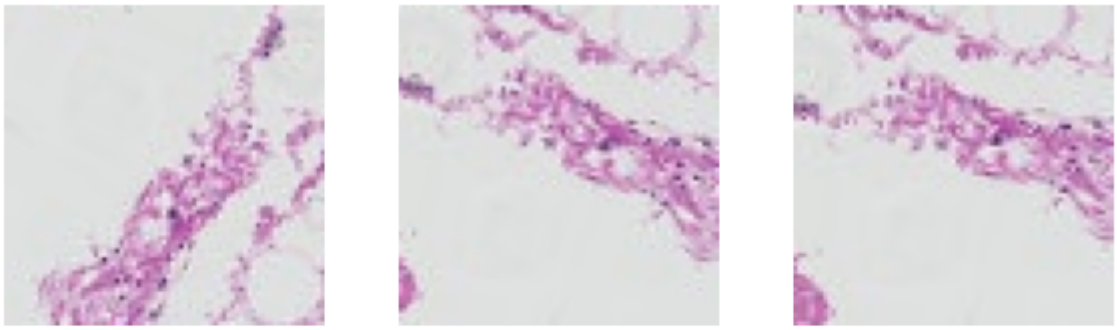
Define the model

Data Augmentation

```
# adding a data augmentation layer to the model
data_augmentation = keras.Sequential(
  [
    layers.experimental.preprocessing.Rescaling(scale=1./255, input_sha
    layers.experimental.preprocessing.RandomFlip("horizontal_and_vertic
    layers.experimental.preprocessing.RandomRotation(0.2),
    # layers.experimental.preprocessing.RandomZoom(0.2)
  ]
)
```

```
time: 148 ms (started: 2021-04-29 17:22:52 +00:00)
```

```
# displaying some patches with data augmentation
plt.figure(figsize=(10, 10))
image = train_slides[19]
for i in range(9):
    image_expand = tf.expand_dims(image, axis=0)
    augmented_images = data_augmentation(image_expand)
    ax = plt.subplot(3, 3, i + 1)
    plt.imshow(augmented_images[0])
    plt.axis("off")
```



Two Inception Models

```
# inception model 1 for level = LEVEL_1 images
base_model_1 = tf.keras.applications.InceptionV3(input_shape=[PATCH_SIZE
base_model_1.trainable = False

# global average layer
global_average_layer = GlobalAveragePooling2D()
dense = Dense(16, activation='relu')

model_1 = Sequential()
model_1.add(data_augmentation)
model_1.add(base_model_1)
model_1.add(global_average_layer)
model_1.add(dense)

level_1_input = Input(shape=(PATCH_SIZE, PATCH_SIZE, 3))
level_1_image = model_1(level_1_input)
```

```
time: 6.89 s (started: 2021-04-29 17:26:18 +00:00)
```

```
# inception model 1 for level = LEVEL_1 images
base_model_2 = tf.keras.applications.InceptionV3(input_shape=[PATCH_SIZE
base_model_2.trainable = False

# global average layer
global_average_layer = GlobalAveragePooling2D()
dense = Dense(16, activation='relu')

model_2 = Sequential()
model_2.add(data_augmentation)
model_2.add(base_model_2)
model_2.add(global_average_layer)
model_2.add(dense)

level_2_input = Input(shape=(PATCH_SIZE, PATCH_SIZE, 3))
```

```
16 level_2_image = model_2(level_2_input)
```

```
time: 5.26 s (started: 2021-04-29 17:26:29 +00:00)
```

```
1 # concatenating the outputs from the two models
2 concat_layer = keras.layers.concatenate([level_1_image, level_2_image])
3 output = Dense(1, activation='sigmoid')(concat_layer)
4
5 # final model
6 model = Model(inputs=[level_1_input, level_2_input], outputs=output)
```

```
time: 34.1 ms (started: 2021-04-29 17:26:36 +00:00)
```

```
1 model.compile(optimizer='adam',
2               loss='binary_crossentropy',
3               metrics=['accuracy'])
```

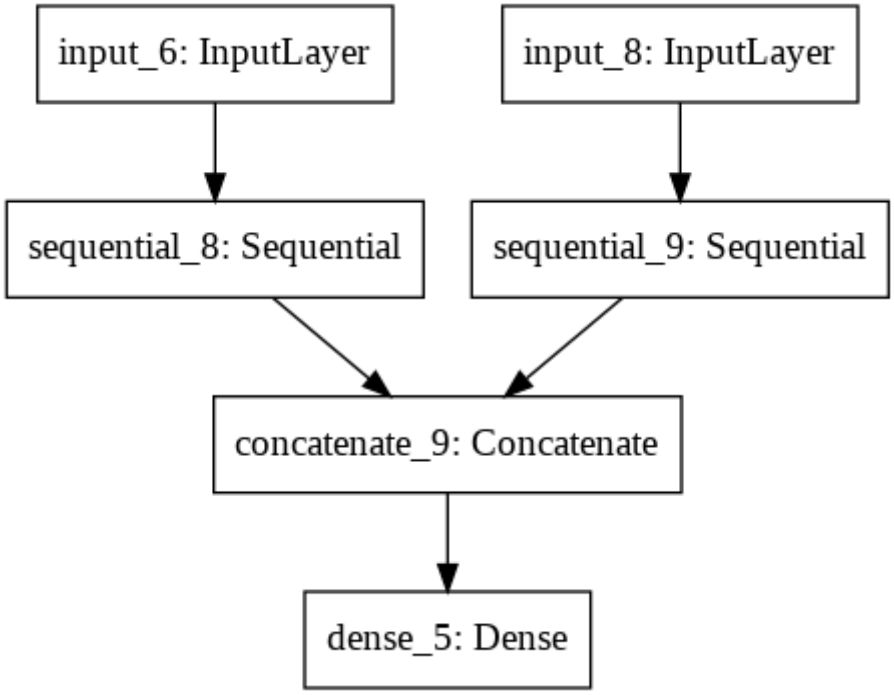
```
time: 28.9 ms (started: 2021-04-29 17:26:39 +00:00)
```

```
1 model.summary()
```

```
Model: "model_1"
__________________________________________________________________________________________________
Layer (type)                    Output Shape         Param #     Connected to
==================================================================================================
input_6 (InputLayer)            [(None, 75, 75, 3)]  0
__________________________________________________________________________________________________
input_8 (InputLayer)            [(None, 75, 75, 3)]  0
__________________________________________________________________________________________________
sequential_8 (Sequential)       (None, 16)           21835568    input_6[0][0]
__________________________________________________________________________________________________
sequential_9 (Sequential)       (None, 16)           21835568    input_8[0][0]
__________________________________________________________________________________________________
concatenate_9 (Concatenate)     (None, 32)           0           sequential_8[0]
                                                                 sequential_9[0]
__________________________________________________________________________________________________
dense_5 (Dense)                 (None, 1)            33          concatenate_9[0
==================================================================================================
Total params: 43,671,169
Trainable params: 65,601
Non-trainable params: 43,605,568
__________________________________________________________________________________________________
time: 66.4 ms (started: 2021-04-29 17:26:40 +00:00)
```

Plot the model for visualization

```
1 from tensorflow.keras.utils import plot_model
2
3 plot_model(model)
```



time: 1.02 s (started: 2021-04-29 17:27:12 +00:00)

Training the model

```
EPOCHS = 10
callbacks = [
    keras.callbacks.ModelCheckpoint("save_at_{epoch}.h5"),
]
history = model.fit(
    [train_slides, train_zoomed_slides],
    train_labels,
    validation_data=([val_slides, val_zoomed_slides], val_labels),
    callbacks=callbacks,
    epochs=EPOCHS
)
```

```
==============================] - 688s 720ms/step - loss: 0.1822 - accuracy: 0.9460

==============================] - 658s 700ms/step - loss: 0.1496 - accuracy: 0.9541

==============================] - 659s 701ms/step - loss: 0.1437 - accuracy: 0.9557

==============================] - 659s 702ms/step - loss: 0.1363 - accuracy: 0.9563

==============================] - 651s 693ms/step - loss: 0.1357 - accuracy: 0.9586

==============================] - 648s 689ms/step - loss: 0.1372 - accuracy: 0.9558

==============================] - 651s 693ms/step - loss: 0.1278 - accuracy: 0.9594
```

```
==========================] - 648s 690ms/step - loss: 0.1380 - accuracy: 0.9550

==========================] - 648s 690ms/step - loss: 0.1295 - accuracy: 0.9584

==========================] - 646s 688ms/step - loss: 0.1261 - accuracy: 0.9597
in 31s (started: 2021-04-29 17:28:15 +00:00)
```

```
# saving the model
save_filepath = os.path.join(dataset_path, 'model/model_2.h5')
model.save(save_filepath)
```

```
time: 2.45 s (started: 2021-04-29 19:23:36 +00:00)
```

Plot the graph for accuracy and loss

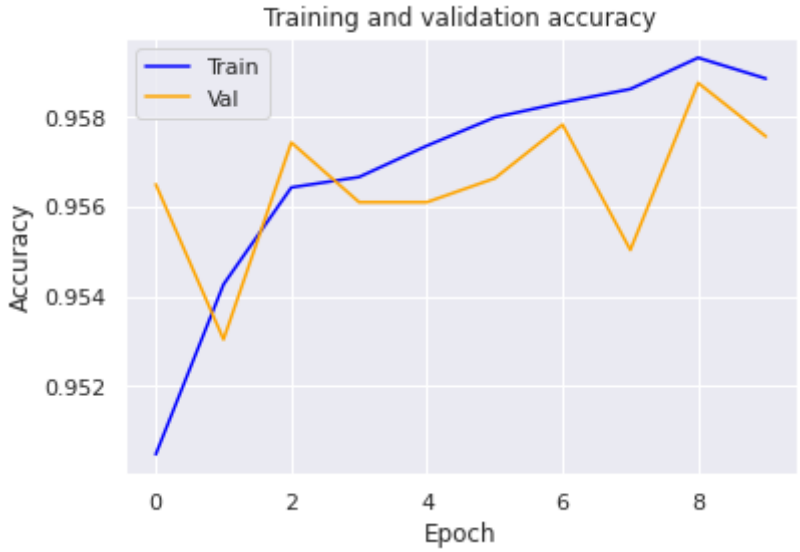
```
# Your code here
acc = history.history['accuracy']
val_acc = history.history['val_accuracy']
loss = history.history['loss']
val_loss = history.history['val_loss']

# Get the number of epochs
epochs = range(len(acc))

plt.title('Training and validation accuracy')
plt.plot(epochs, acc, color='blue', label='Train')
plt.plot(epochs, val_acc, color='orange', label='Val')
plt.xlabel('Epoch')
plt.ylabel('Accuracy')
plt.legend()

_ = plt.figure()
plt.title('Training and validation loss')
plt.plot(epochs, loss, color='blue', label='Train')
plt.plot(epochs, val_loss, color='orange', label='Val')
plt.xlabel('Epoch')
plt.ylabel('Loss')
plt.legend()
```

```
<matplotlib.legend.Legend at 0x7fe755b6d450>
```



Test the model on the test data

```
# loading the test tif files to be used for plotting
test_tumor_path = os.path.join(dataset_path, 'test/tumor')
test_tumor_mask_path = os.path.join(dataset_path, 'test/tumor_mask')

test_tumors_tifs = []
test_tumors_mask_tifs = []

for filename in os.listdir(test_tumor_path):
    test_tumors_tifs.append(os.path.join(test_tumor_path, filename))
for filename in os.listdir(test_tumor_mask_path):
    test_tumors_mask_tifs.append(os.path.join(test_tumor_mask_path, file

test_tumors_tifs.sort()
test_tumors_mask_tifs.sort()
print("Length of test tumor tiffs: {}".format(len(test_tumors_tifs)))
print("Length of test tumor mask tiffs: {}".format(len(test_tumors_mask_
```

```
Length of test tumor tiffs: 2
Length of test tumor mask tiffs: 2
time: 23 ms (started: 2021-04-29 19:38:20 +00:00)
```

```
# create separate test_slides and test_labels for each of the two test t

# this corresponds to the number of patches in the row and column of eac
# tif file.
stride_width_array = [116, 78]
stride_height_array = [59, 59]

first_index = stride_height_array[0]*stride_width_array[0]
test_slides_normal_1 = test_slides[:first_index]
test_labels_normal_1 = test_labels[:first_index]

test_slides_normal_2 = test_slides[first_index:]
test_labels_normal_2 = test_labels[first_index:]

print("first_tiff_index: ", first_index)
print("length: ", test_labels_normal_1)
print(np.sum(test_labels_normal_1))

print("length: ", test_labels_normal_2)
print(np.sum(test_labels_normal_2))
```

```
first_tiff_index:  6844
length:  [0 0 0 ... 0 0 0]
222
length:  [0 0 0 ... 0 0 0]
927
time: 19.5 ms (started: 2021-04-29 19:38:26 +00:00)
```

```
# create separate test_slides and test_labels for each of the two test t
# stride_width_array_zoom = [232, 157]
# stride_height_array_zoom = [119, 119]

# first_tiff_index = PATCH_SIZE * stride_width_array[0] + PATCH_SIZE * s
# first_index = stride_height_array_zoom[0]*stride_width_array_zoom[0]
test_slides_zoomed_1 = test_zoomed_slides[:first_index]
test_labels_zoomed_1 = test_labels[:first_index]

test_slides_zoomed_2 = test_zoomed_slides[first_index:]
test_labels_zoomed_2 = test_labels[first_index:]

print("first_tiff_index: ", first_index)
print("length: ", test_labels_zoomed_1)
print(np.sum(test_labels_zoomed_1))

print("length: ", test_labels_zoomed_2)
print(np.sum(test_labels_zoomed_2))
```

```
first_tiff_index:  6844
length:  [0 0 0 ... 0 0 0]
222
length:  [0 0 0 ... 0 0 0]
927
time: 16.5 ms (started: 2021-04-29 19:38:30 +00:00)
```

Predicting the first test tiff file.

```
predictions = model.predict([test_slides_normal_1, test_slides_zoomed_1
```

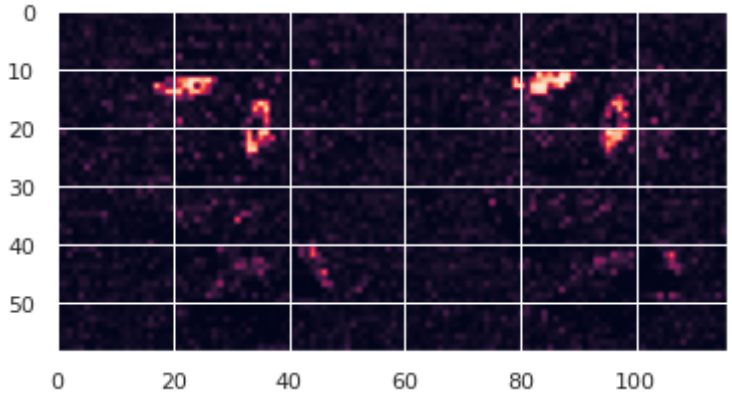
```
time: 1min 54s (started: 2021-04-29 19:38:33 +00:00)
```

```
print("length of predictions: {}".format(len(predictions)))
print("predictions: {}".format(predictions))
```

```
length of predictions: 6844
predictions: [[0.02210265]
 [0.01815641]
 [0.04221612]
 ...
 [0.01344201]
 [0.01127237]
 [0.00645652]]
time: 15.6 ms (started: 2021-04-29 19:40:46 +00:00)
```

```
plt.imshow(np.reshape(predictions, (116, 59)).T)
```

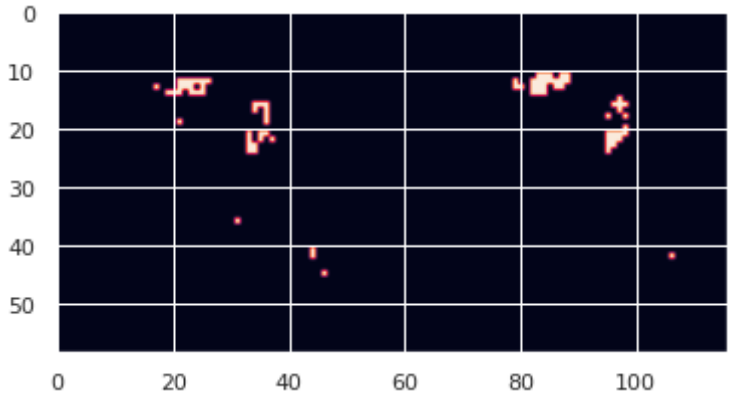
```
<matplotlib.image.AxesImage at 0x7fe756a17c90>
```




```
time: 468 ms (started: 2021-04-29 19:40:49 +00:00)
```

```
# plotting the thresholded
THRESHOLD = 0.5
threshold_predictions = np.where(predictions > THRESHOLD, 1, 0)
plt.imshow(np.reshape(threshold_predictions, (116, 59)).T)
```

```
<matplotlib.image.AxesImage at 0x7fe75695e310>
```




```
time: 438 ms (started: 2021-04-29 19:41:03 +00:00)
```

F1-Score

```
from sklearn.metrics import classification_report

classification_metrics = classification_report(threshold_predictions, te
print(classification_metrics)
```

```
              precision    recall  f1-score   support

           0       1.00      0.98      0.99      6763
           1       0.34      0.94      0.50        81

    accuracy                           0.98      6844
   macro avg       0.67      0.96      0.75      6844
weighted avg       0.99      0.98      0.98      6844

time: 25.3 ms (started: 2021-04-29 20:02:20 +00:00)
```

Intersection over Union Score

```
y_pred_image = np.reshape(threshold_predictions, (116, 59))
y_true_image = np.reshape(test_labels_normal_1, (116, 59))

inter = np.logical_and(y_pred_image, y_true_image)
union = np.logical_or(y_pred_image, y_true_image)

print(np.sum(inter)/float(np.sum(union)))
```

```
0.33480176211453744
time: 6.04 ms (started: 2021-04-29 20:08:58 +00:00)
```

Heatmap For The test tiff

```
# read slide and return an image
def read_slide(slide, x, y, level, width, height, as_float=False):
    im = slide.read_region((x,y), level, (width, height))
    im = im.convert('RGB') # drop the alpha channel
    if as_float:
        im = np.asarray(im, dtype=np.float32)
    else:
        im = np.asarray(im)
    assert im.shape == (height, width, 3)
    return im
```

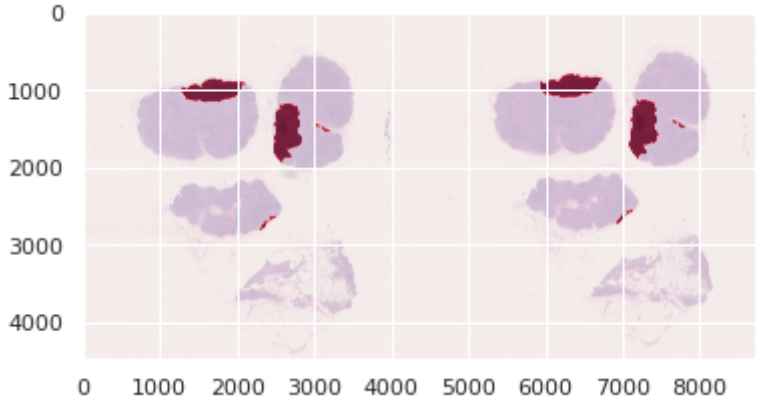
time: 7.23 ms (started: 2021-04-29 19:41:10 +00:00)

```
# show a slide
tumor_image = open_slide(test_tumors_tifs[0])
mask_image = open_slide(test_tumors_mask_tifs[0])

width = tumor_image.level_dimensions[LEVEL_1][0]
height = tumor_image.level_dimensions[LEVEL_1][1]

tumor_slide = read_slide(tumor_image, 0, 0, LEVEL_1, width=width, height
mask_slide = read_slide(mask_image, 0, 0, LEVEL_1, width=width, height=h

plt.imshow(tumor_slide)
plt.imshow(mask_slide[:, :, 0], cmap='Reds', alpha=0.7)
plt.show()
```



time: 9.54 s (started: 2021-04-29 19:41:12 +00:00)

```
# plot the patches to see if patch extraction is working properly
step_width = width // PATCH_SIZE
step_height = height // PATCH_SIZE
canvas_slide = Image.new('RGB', (PATCH_SIZE * step_width, PATCH_SIZE * s
canvas_mask = Image.new('RGB', (PATCH_SIZE * step_width, PATCH_SIZE * st
mask_blank = np.zeros((PATCH_SIZE, PATCH_SIZE))
mask_tumor = 255 * np.ones((PATCH_SIZE, PATCH_SIZE))
```

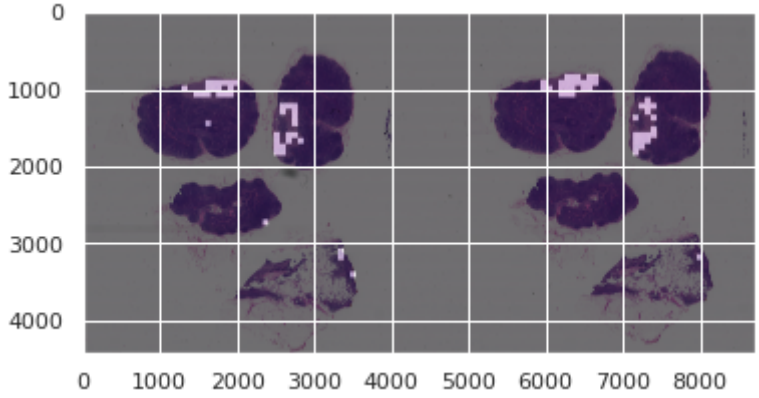
```
index = 0

for i in range(step_width):
    for j in range(step_height):
        canvas_slide.paste(Image.fromarray(test_slides_normal_1[index],
        if temp[index] == 0:
            canvas_mask.paste(Image.fromarray(mask_blank), (i*PATCH_SIZ
        else:
            canvas_mask.paste(Image.fromarray(mask_tumor), (i*PATCH_SIZ
        index += 1

slide_name = 'patch_to_slide.png'
mask_name = 'patch_to_mask.png'
canvas_slide.save(slide_name)
canvas_mask.save(mask_name)
image_slide = plt.imread(slide_name)
image_mask = plt.imread(mask_name)

plt.imshow(image_slide)
plt.imshow(image_mask, cmap='Reds', alpha=0.5)
```

```
<matplotlib.image.AxesImage at 0x7fe7568c2550>
```




```
time: 30.9 s (started: 2021-04-29 19:41:45 +00:00)
```

Predicting the second tiff file

```
predictions_2 = model.predict([test_slides_normal_2, test_slides_zoomed_
```

```
time: 1min 15s (started: 2021-04-29 19:42:45 +00:00)
```

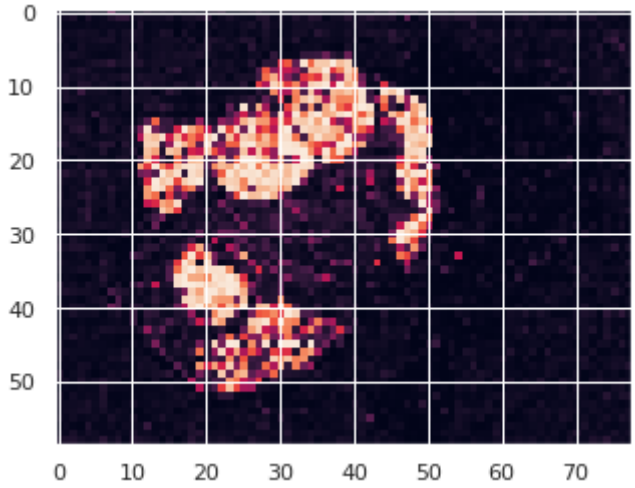
```
print("length of predictions: {}".format(len(predictions_2)))
print("predictions: {}".format(predictions_2))
```

```
length of predictions: 4602
predictions: [[0.04947379]
```

```
 [0.03780037]
 [0.02027133]
 ...
 [0.02750137]
 [0.04804933]
 [0.02972835]]
time: 15.6 ms (started: 2021-04-29 19:44:13 +00:00)
```

```
1 plt.imshow(np.reshape(predictions_2, (78, 59)).T)
```

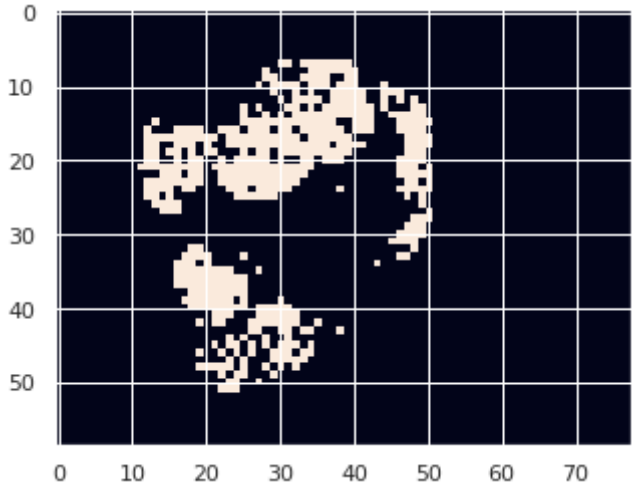
```
<matplotlib.image.AxesImage at 0x7fe7567d1190>
```




```
time: 436 ms (started: 2021-04-29 19:44:15 +00:00)
```

```
1 THRESHOLD = 0.5
2 threshold_predictions = np.where(predictions_2 > THRESHOLD, 1, 0)
3 plt.imshow(np.reshape(threshold_predictions, (78, 59)).T)
```

```
<matplotlib.image.AxesImage at 0x7fe7567ff690>
```




```
time: 526 ms (started: 2021-04-29 19:44:29 +00:00)
```

Heatmap For The test tiff

```
# read slide and return an image
def read_slide(slide, x, y, level, width, height, as_float=False):
    im = slide.read_region((x,y), level, (width, height))
    im = im.convert('RGB') # drop the alpha channel
    if as_float:
        im = np.asarray(im, dtype=np.float32)
    else:
        im = np.asarray(im)
    assert im.shape == (height, width, 3)
    return im
```

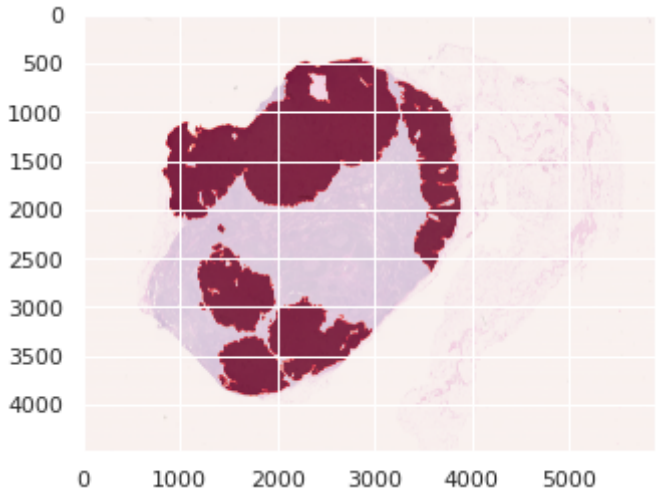
time: 15.3 ms (started: 2021-04-29 19:44:37 +00:00)

```
# show a slide
tumor_image = open_slide(test_tumors_tifs[1])
mask_image = open_slide(test_tumors_mask_tifs[1])

width = tumor_image.level_dimensions[LEVEL_1][0]
height = tumor_image.level_dimensions[LEVEL_1][1]

tumor_slide = read_slide(tumor_image, 0, 0, LEVEL_1, width=width, height
mask_slide = read_slide(mask_image, 0, 0, LEVEL_1, width=width, height=h

plt.imshow(tumor_slide)
plt.imshow(mask_slide[:, :, 0], cmap='Reds', alpha=0.7)
plt.show()
```



time: 6.8 s (started: 2021-04-29 19:44:39 +00:00)

```
plot the patches to see if patch extraction is working properly
tep_width = width // PATCH_SIZE
tep_height = height // PATCH_SIZE
anvas_slide = Image.new('RGB', (PATCH_SIZE * step_width, PATCH_SIZE * st
anvas_mask = Image.new('RGB', (PATCH_SIZE * step_width, PATCH_SIZE * ste
```

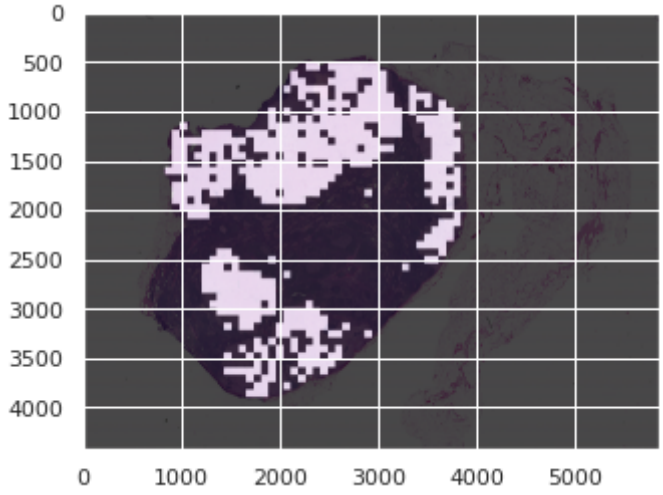
```
ask_blank = np.zeros((PATCH_SIZE, PATCH_SIZE))
ask_tumor = 255 * np.ones((PATCH_SIZE, PATCH_SIZE))
ndex = 0

or i in range(step_width):
   for j in range(step_height):
       canvas_slide.paste(Image.fromarray(test_slides_normal_2[index],
       if temp_2[index] == 0:
           canvas_mask.paste(Image.fromarray(mask_blank), (i*PATCH_SIZE
       else:
           canvas_mask.paste(Image.fromarray(mask_tumor), (i*PATCH_SIZE
       index += 1

lide_name = 'patch_to_slide.png'
ask_name = 'patch_to_mask.png'
anvas_slide.save(slide_name)
anvas_mask.save(mask_name)
mage_slide = plt.imread(slide_name)
mage_mask = plt.imread(mask_name)

lt.imshow(image_slide)
lt.imshow(image_mask, cmap='Reds', alpha=0.7)
```

```
<matplotlib.image.AxesImage at 0x7fe7566f1a10>
```




```
time: 20 s (started: 2021-04-29 19:44:59 +00:00)
```