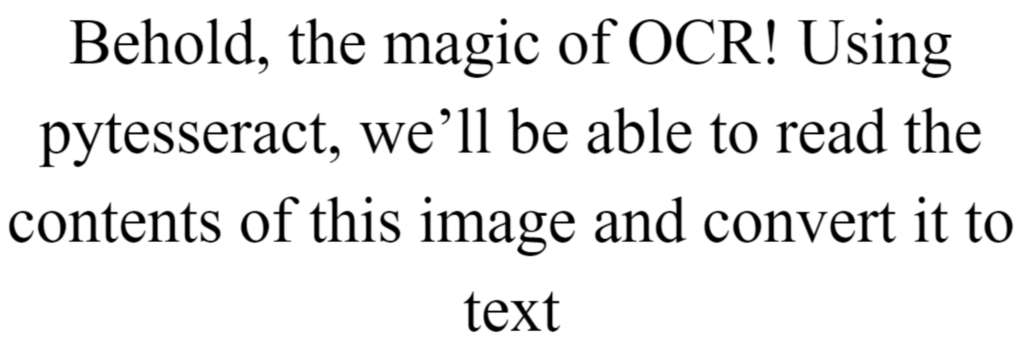
module_2

July 16, 2020

0.1 Lecture: The (Py)Tesseract Library

In [1]:
```
# We're going to start experimenting with tesseract using just a simple image of nice
# Lets first import Image from PIL and display the image text.png.
from PIL import Image

image = Image.open("readonly/text.png")
display(image)
```



In [2]:
```
# Great, we have a base image of some big clear text
# Lets import pytesseract and use the dir() fundtion to get a sense of what might be s
# functions to play with
import pytesseract
dir(pytesseract)
```

Out[2]:
```
['Output',
 'TesseractError',
 '__builtins__',
 '__cached__',
 '__doc__',
 '__file__',
 '__loader__',
 '__name__',
```

```
 '__package__',
 '__path__',
 '__spec__',
 'get_tesseract_version',
 'image_to_boxes',
 'image_to_data',
 'image_to_osd',
 'image_to_pdf_or_hocr',
 'image_to_string',
 'pytesseract']
```

In [4]:
```
# It looks like there are just a handful of interesting functions, and I think image_t
# is probably our best bet. Lets use the help() function to interrogate this a bit mor
help(pytesseract.image_to_string)
```

```
Help on function image_to_string in module pytesseract.pytesseract:

image_to_string(image, lang=None, config='', nice=0, output_type='string')
    Returns the result of a Tesseract OCR run on the provided image to string
```

In [5]:
```
# So this function takes an image as the first parameter, then there are a bunch of op
# and it will return the results of the OCR. I think it's worth comparing this documen
# with the documentation we were receiving from the PILLOW module. Lets run the help c
# Image resize function()
help(Image.Image.resize)
```

```
Help on function resize in module PIL.Image:

resize(self, size, resample=0, box=None)
    Returns a resized copy of this image.

    :param size: The requested size in pixels, as a 2-tuple:
       (width, height).
    :param resample: An optional resampling filter.  This can be
       one of :py:attr:`PIL.Image.NEAREST`, :py:attr:`PIL.Image.BOX`,
       :py:attr:`PIL.Image.BILINEAR`, :py:attr:`PIL.Image.HAMMING`,
       :py:attr:`PIL.Image.BICUBIC` or :py:attr:`PIL.Image.LANCZOS`.
       If omitted, or if the image has mode "1" or "P", it is
       set :py:attr:`PIL.Image.NEAREST`.
       See: :ref:`concept-filters`.
    :param box: An optional 4-tuple of floats giving the region
       of the source image which should be scaled.
       The values should be within (0, 0, width, height) rectangle.
       If omitted or None, the entire source is used.
    :returns: An :py:class:`~PIL.Image.Image` object.
```

In [6]:
```python
# Notice how the PILLOW function has a bit more information in it. First it's using a
# called reStructuredText, which is similar in intent to document markups such as HTML
# the web. The intent is to embed semantics in the documentation itself. For instance,
# function we see the words "param size" with colons surrounding it. This allows docum
# which create web docs from source code to link the parameter to the extended docs ab
# In this case the extended docs tell us that the size should be passed as a tuple of
# Notice how the docs for image_to_string, for instance, indicate that there is a "lan
# use, but then fail to say anything about what that parameter is for or what its form
#
# What this really means is that we need to dig deeper. Here's a quick hack if you wan
# source code of a function -- you can use the inspect getsource() command and print t
import inspect
src = inspect.getsource(pytesseract.image_to_string)
print(src)
```

```
def image_to_string(image,
                    lang=None,
                    config='',
                    nice=0,
                    output_type=Output.STRING):
    '''
    Returns the result of a Tesseract OCR run on the provided image to string
    '''
    args = [image, 'txt', lang, config, nice]

    return {
        Output.BYTES: lambda: run_and_get_output(*(args + [True])),
        Output.DICT: lambda: {'text': run_and_get_output(*args)},
        Output.STRING: lambda: run_and_get_output(*args),
    }[output_type]()
```

In [7]:
```python
# There's actually another way in jupyter, and that's to append *two* question marks t
# a given function or module. Other editors have similar features, and is a great reas
# software development environment
pytesseract.image_to_string??
```

In [8]:
```python
# We can see from the source code that there really isn't much more information about
# are for this image_to_string function. This is because underneath the pytesseract li
# library which does all of the hard work, and the author just passes through all of t
# underlying tesseract executable. This is a common issue when working with python lib
# we need to do some web sleuthing in order to understand how we can interact with tes
#
# In a case like this I just googled "tesseract command line parameters" and the first
# looking for, here's the URL: https://github.com/tesseract-ocr/tesseract/wiki/Command
#
# This goes to a wiki page which describes how to call the tesseract executable, and a
```

```
# that we can actually have tesseract use multiple languages in its detection, such as
# passing them in as "eng+hin". Very cool.
```

```
In [9]: # One last thing to mention - the image_to_string() function takes in an "image", but
        # really describe what this image is underneath. Is it a string to an image file? A PI
        # Something else?
        #
        # Again we have to sleuth (and/or experiment) to understand what we should do. If we l
        # code for the pytesseract library, we see that there is a function called run_and_get
        # a link to that function on the author's github account:
        # https://github.com/madmaze/pytesseract/blob/d1596f7f59a517ad814b7d810ccdef7d33763221
        #
        # In this function we see that one of the first things which happens is the image is s
        # the save_image() function. Here's that line of code:
        # https://github.com/madmaze/pytesseract/blob/d1596f7f59a517ad814b7d810ccdef7d33763221
        #
        # And we see there that another function is called, prepare(image), which actually loa
        # PILLOW image file. So yes, sending a PIL image file is appropriate use for this func
        # have been useful for the author to have included this information in reStructuredTex
        # to dig through the implementation. But, this is an open source project -- maybe you
        # back better documentation?
        #
        # Hint: The doc line we needed was :param image: A PIL Image.Image file or an ndarray
        #
        # In the end, we often don't do this full level of investigation, and we just experime
        # seems likely that a PIL Image.Image would work, given how well known PIL is in the p
        # as you explore and use different libraries you'll see a breadth of different documen
        # useful to know how to explore the source code. And now that you're at the end of thi
        # the skills to do so!
        #
        # Ok, lets try and run tesseract on this image
        text = pytesseract.image_to_string(image)
        print(text)
```

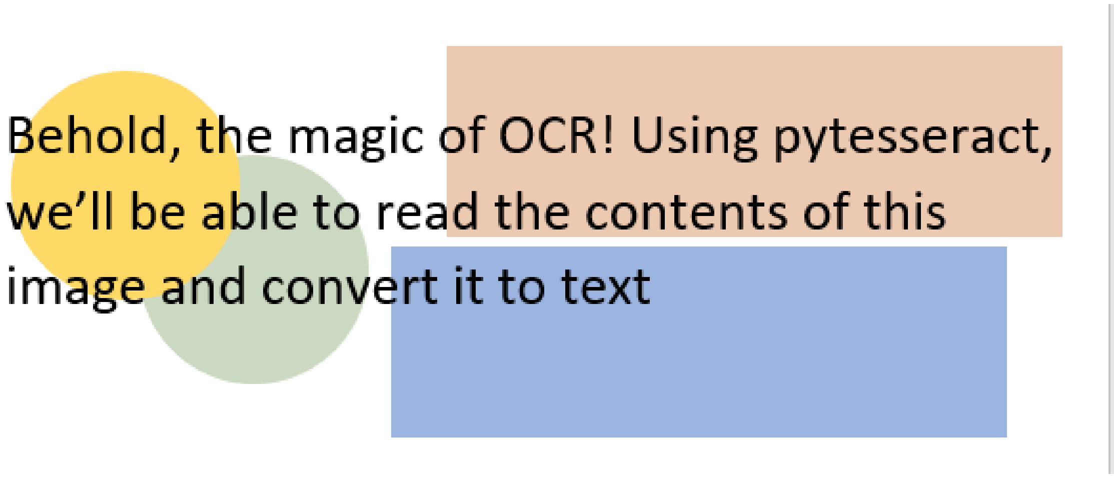
```
Behold, the magic of OCR! Using
pytesseract, well be able to read the
contents of this image and convert it to
text
```

```
In [10]: # Looks great! We see that the output includes new line characters, and faithfully re
         # but doesn't include any special formatting. Lets go on and look at something with a
```

0.2 More Tesseract

```
In [11]: # In the previous example, we were using a clear, unambiguous image for conversion. S
         # be noise in images you want to OCR, making it difficult to extract the text. Lucki
         # techniques we can use to increase the efficacy of OCR with pytesseract and Pillow.
         #
```

```
# Let's use a different image this time, with the same text as before but with added 
# We can view this image using the following code.
from PIL import Image
img = Image.open("readonly/Noisy_OCR.PNG")
display(img)
```

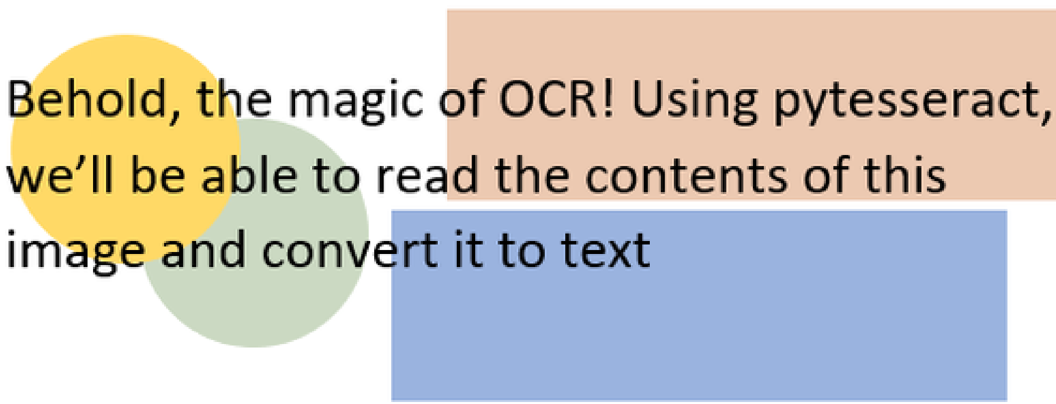



```
In [12]: # As you can see, this image had shapes of different opacities behind the text, which
         # the tesseract engine. Let's see if OCR will work on this noisy image
         import pytesseract
         text = pytesseract.image_to_string(Image.open("readonly/Noisy_OCR.PNG"))
         print(text)
```

```
e magic of OCR! Using pytesseract,
le to read the contents of this



d convert it to text
```

```
In [13]: # This is a bit surprising given how nicely tesseract worked previously! Let's experi
         # using techniqes that will allow for more effective image analysis. First up, lets c
         # the image

In [14]: # First we will import PIL
         import PIL
         # Then set the base width of our image
         basewidth = 600
         # Now lets open it
         img = Image.open("readonly/Noisy_OCR.PNG")
         # We want to get the correct aspect ratio, so we can do this by taking the base width
         # it by the actual width of the image
```

```
    wpercent = (basewidth / float(img.size[0]))
    # With that ratio we can just get the appropriate height of the image.
    hsize = int((float(img.size[1]) * float(wpercent)))
    # Finally, lets resize the image. antialiasing is a specific way of resizing lines to
    # appear smooth
    img = img.resize((basewidth, hsize), PIL.Image.ANTIALIAS)
    # Now lets save this to a file
    img.save('resized_nois.png') # save the image as a jpg
    # And finally, lets display it
    display(img)
    # and run OCR
    text = pytesseract.image_to_string(Image.open('resized_nois.png'))
    print(text)
```




```
e magic of OCR! Using pytesseract,
le to read the contents of this
d convert it to text
```

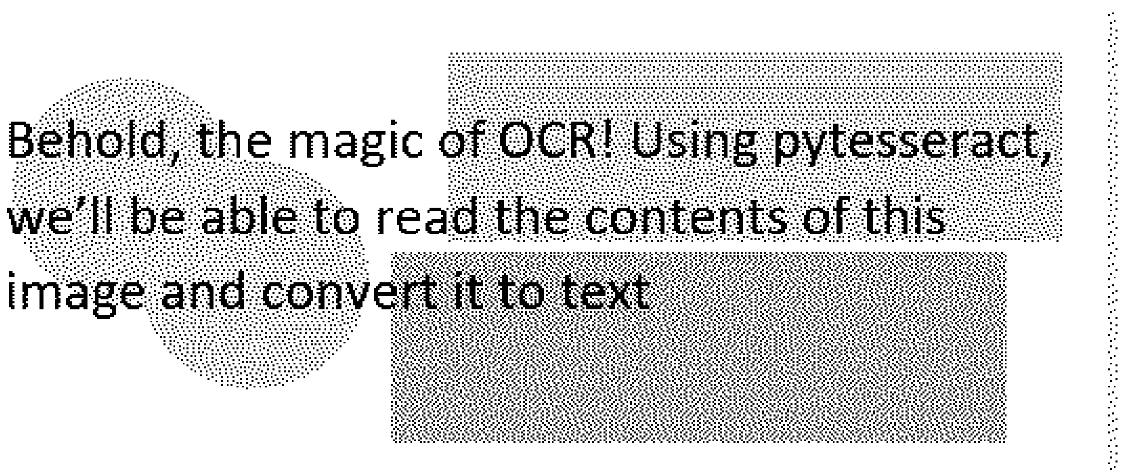
```
In [15]: # hrm, no improvement for resizing the image. Let's convert the image to greyscale. C
         # can be done in many different ways. If we poke around in the PILLOW documentation w
         # the easiest ways to do this is to use the convert() function and pass in the string
         img = Image.open('readonly/Noisy_OCR.PNG')
         img = img.convert('L')
         # Now lets save that image
         img.save('greyscale_noise.jpg')
         # And run OCR on the greyscale image
         text = pytesseract.image_to_string(Image.open('greyscale_noise.jpg'))
         print(text)
```

```
Behold, the magic of OCR! Using pytesseract,
we'll be able to read the contents of this
```

image and convert it to text

In [16]:
```
# Wow, that worked really well! If we look at the help documentation using the help f
# as in help(img.convert) we see that the conversion mechanism is the ITU-R 601-2 lum
# There's more information about this out there, but this method essentially takes a
# where there is information for the amount of red, green, and blue (R, G, and B), an
# to a single channel to represent luminosity. This method actually comes from how st
# definition television sets encoded color onto black and while images. If you get re
# in image manipulation and recognition, learning about color spaces and how we repre
# computationally and through human perception, is really an interesting field.
```

In [17]:
```
# Even though we have now the complete text of the image, there are a few other techn
# we could use to help improve OCR detection in the event that the above two don't he
# The next approach I would use is called binarization, which means to separate into
# distinct parts - in this case, black and white. Binarization is enacted through a p
# called thresholding. If a pixel value is greater than a threshold value, it will be
# to a black pixel; if it is lower than the threshold it will be converted to a white
# This process eliminates noise in the OCR process allowing greater image recognition
# With Pillow, this process is straightforward.
# Lets open the noisy impage and convert it using binarization
img = Image.open('readonly/Noisy_OCR.PNG').convert('1')
# Now lets save and display that image
img.save('black_white_noise.jpg')
display(img)
```



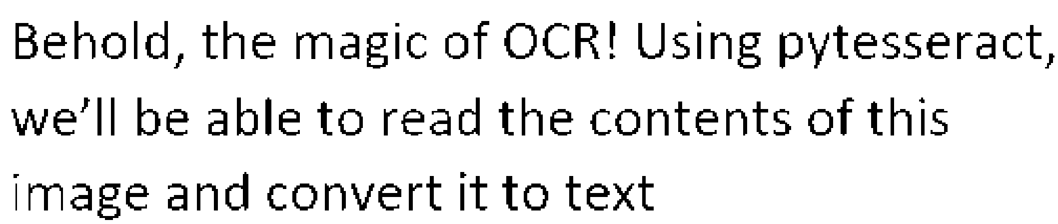
In [18]:
```
# So, that was a bit magical, and really required a fine reading of the docs to figur
# that the number "1" is a string parameter to the convert function actually does the
# But you actually have all of the skills you need to write this functionality yourse
# Lets walk through an example. First, lets define a function called binarize, which
# an image and a threshold value:
```

```python
def binarize(image_to_transform, threshold):
    # now, lets convert that image to a single greyscale image using convert()
    output_image=image_to_transform.convert("L")
    # the threshold value is usually provided as a number between 0 and 255, which
    # is the number of bits in a byte.
    # the algorithm for the binarization is pretty simple, go through every pixel in
    # image and, if it's greater than the threshold, turn it all the way up (255), and
    # if it's lower than the threshold, turn it all the way down (0).
    # so lets write this in code. First, we need to iterate over all of the pixels in
    # image we want to work with
    for x in range(output_image.width):
        for y in range(output_image.height):
            # for the given pixel at w,h, lets check its value against the threshold
            if output_image.getpixel((x,y))< threshold: #note that the first paramete
                # lets set this to zero
                output_image.putpixel( (x,y), 0 )
            else:
                # otherwise lets set this to 255
                output_image.putpixel( (x,y), 255 )
    #now we just return the new image
    return output_image

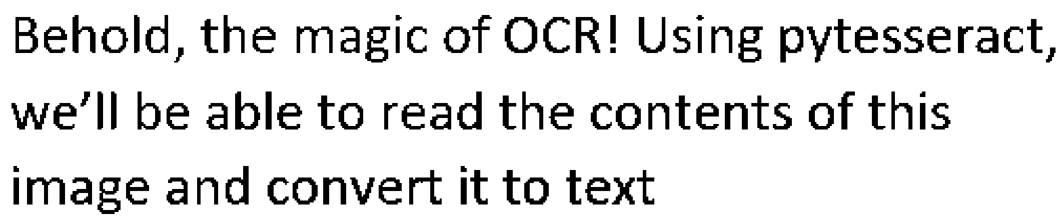
# lets test this function over a range of different thresholds. Remember that you can
# the range() function to generate a list of numbers at different step sizes. range()
# with a start, a stop, and a step size. So lets try range(0, 257, 64), which should
# images of different threshold values
for thresh in range(0,257,64):
    print("Trying with threshold " + str(thresh))
    # Lets display the binarized image inline
    display(binarize(Image.open('readonly/Noisy_OCR.PNG'), thresh))
    # And lets use tesseract on it. It's inefficient to binarize it twice but this is
    # a demo
    print(pytesseract.image_to_string(binarize(Image.open('readonly/Noisy_OCR.PNG'), 
```

```
Trying with threshold 0
```

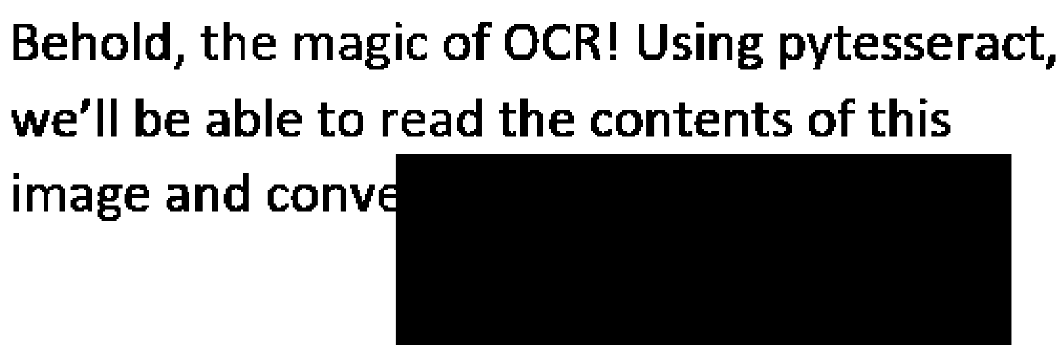
```
Trying with threshold 64
```




```
Behold, the magic of OCR! Using pytesseract,
well be able to read the contents of this
image and convert it to text
Trying with threshold 128
```




```
Behold, the magic of OCR! Using pytesseract,
we'll be able to read the contents of this
image and convert it to text
Trying with threshold 192
```




```
Behold, the magic of OCR! Using pytesseract,
well be able to read the contents of this
image and conv
Trying with threshold 256
```

```
In [19]: # We can see from this that a threshold of 0 essentially turns everything white,
         # that the text becomes more bold as we move towards a higher threshold, and that
         # the shapes, which have a filled in grey color, become more evident at higher
         # thresholds. In the next lecture we'll look a bit more at some of the challenges
         # you can expect when doing OCR on real data
```

0.3 Tesseract and Photographs

```
In [20]: # Lets try a new example and bring together some of the things we have learned.
         # Here's an image of a storefront, lets load it and try and get the name of the
         # store out of the image
         from PIL import Image
         import pytesseract
         # Lets read in the storefront image I've loaded into the course and display it
         image=Image.open('readonly/storefront.jpg')
         display(image)
         # Finally, lets try and run tesseract on that image and see what the results are
         pytesseract.image_to_string(image)
```


```
Out[20]: ''

In [21]: # We see at the very bottom there is just an empty string. Tesseract is unable to tak
         # this image and pull out the name. But we learned how to crop the images in the
         # last set of lectures, so lets try and help Tesseract by cropping out certain pieces
         #
         # First, lets set the bounding box. In this image the store name is in a box
         # bounded by (315, 170, 700, 270)
         bounding_box=(315, 170, 700, 270)

         # Now lets crop the image
         title_image=image.crop(bounding_box)

         # Now lets display it and pull out the text
         display(title_image)
         pytesseract.image_to_string(title_image)
```

Out[21]: 'FOSSIL'

In [22]:
```
# Great, we see how with a bit of a problem reduction we can make that work. So now w
# been able to take an image, preprocess it where we expect to see text, and turn tha
# into a string that python can understand.
#
# If you look back up at the image though, you'll see there is a small sign inside of
# shop that also has the shop name on it. I wonder if we're able to recognize the tex
# that sign? Let's give it a try.
#
# First, we need to determine a bounding box for that sign. I'm going to show you a s
# to make this easier in an optional video in this module, but for now lets just use
# box I decided on
bounding_box=(900, 420, 940, 445)

# Now, lets crop the image
little_sign=image.crop((900, 420, 940, 445))
display(little_sign)
```

In [23]:
```
# All right, that is a little sign! OCR works better with higher resolution images, s
# lets increase the size of this image by using the pillow resize() function
# Lets set the width and height equal to ten times the size it is now in a (w,h) tupl
new_size=(little_sign.width*10,little_sign.height*10)

# Now lets check the docs for resize()
help(little_sign.resize)
```

```
Help on method resize in module PIL.Image:

resize(size, resample=0, box=None) method of PIL.Image.Image instance
    Returns a resized copy of this image.
```

```
:param size: The requested size in pixels, as a 2-tuple:
   (width, height).
:param resample: An optional resampling filter.  This can be
   one of :py:attr:`PIL.Image.NEAREST`, :py:attr:`PIL.Image.BOX`,
   :py:attr:`PIL.Image.BILINEAR`, :py:attr:`PIL.Image.HAMMING`,
   :py:attr:`PIL.Image.BICUBIC` or :py:attr:`PIL.Image.LANCZOS`.
   If omitted, or if the image has mode "1" or "P", it is
   set :py:attr:`PIL.Image.NEAREST`.
   See: :ref:`concept-filters`.
:param box: An optional 4-tuple of floats giving the region
   of the source image which should be scaled.
   The values should be within (0, 0, width, height) rectangle.
   If omitted or None, the entire source is used.
:returns: An :py:class:`~PIL.Image.Image` object.
```

In [24]:
```
# We can see that there are a number of different filters for resizing the image. The
# default is Image.NEAREST. Lets see what that looks like
display(little_sign.resize( new_size, Image.NEAREST))
```

In [25]:
```
# I think we should be able to find something better. I can read it, but it looks
# really pixelated. Lets see what all the different resize options look like
options=[Image.NEAREST, Image.BOX, Image.BILINEAR, Image.HAMMING, Image.BICUBIC, Image
for option in options:
```

```
    # lets print the option name
    print(option)
    # lets display what this option looks like on our little sign
    display(little_sign.resize( new_size, option))
```

```
0
```

```
4
```

2

5

3

1

In [26]:
```
# From this we can notice two things. First, when we print out one of the resampling
# values it actually just prints an integer! This is really common: that the
# API developer writes a property, such as Image.BICUBIC, and then assigns it to an
# integer value to pass it around. Some languages use enumerations of values, which i
# common in say, Java, but in python this is a pretty normal way of doing things.
# The second thing we learned is that there are a number of different algorithms for
# image resampling. In this case, the Image.LANCZOS and Image.BICUBIC filters do a go
# job. Lets see if we are able to recognize the text off of this resized image

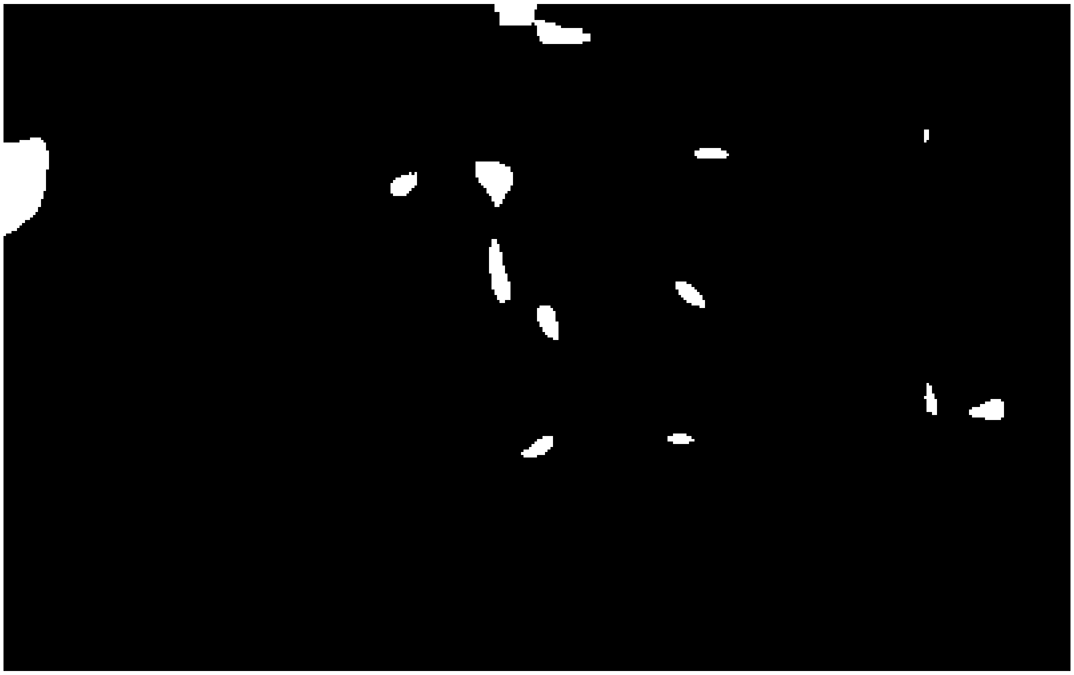
# First lets resize to the larger size
bigger_sign=little_sign.resize(new_size, Image.BICUBIC)
# Lets print out the text
pytesseract.image_to_string(bigger_sign)
```

Out[26]:
```
''
```

In [27]:
```
# Well, no text there. Lets try and binarize this. First, let me just bring in the
# binarization code we did earlier
def binarize(image_to_transform, threshold):
    output_image=image_to_transform.convert("L")
    for x in range(output_image.width):
        for y in range(output_image.height):
            if output_image.getpixel((x,y))< threshold:
                output_image.putpixel( (x,y), 0 )
            else:
                output_image.putpixel( (x,y), 255 )
```

```
    return output_image

# Now, lets apply binarizations with, say, a threshold of 190, and try and display th
# as well as do the OCR work
binarized_bigger_sign=binarize(bigger_sign, 190)
display(binarized_bigger_sign)
pytesseract.image_to_string(binarized_bigger_sign)
```



Out[27]: 'Lae'

In [28]:
```
# Ok, that text is pretty useless. How should we pick the best binarization
# to use? Well, there are some methods, but lets just try something very simple to
# show how well this can work. We have an english word we are trying to detect, "FOSS
# If we tried all binarizations, from 0 through 255, and looked to see if there were
# any english words in that list, this might be one way. So lets see if we can
# write a routine to do this.
#
# First, lets load a list of english words into a list. I put a copy in the readonly
# directory for you to work with
eng_dict=[]
with open ("readonly/words_alpha.txt", "r") as f:
    data=f.read()
    # now we want to split this into a list based on the new line characters
    eng_dict=data.split("\n")

# Now lets iterate through all possible thresholds and look for an english word, prin
```

```
        # it out if it exists
        for i in range(150,170):
            # lets binarize and convert this to s tring values
            strng=pytesseract.image_to_string(binarize(bigger_sign,i))
            # We want to remove non alphabetical characters, like ([%$]) from the text, here'
            # a short method to do that
            # first, lets convert our string to lower case only
            strng=strng.lower()
            # then lets import the string package - it has a nice list of lower case letters
            import string
            # now lets iterate over our string looking at it character by character, putting
            # the comaprison text
            comparison=''
            for character in strng:
                if character in string.ascii_lowercase:
                    comparison=comparison+character
            # finally, lets search for comparison in the dictionary file
            if comparison in eng_dict:
                # and print it if we find it
                print(comparison)
```

```
fossil
si
fossil
fossil
gas
gas
sl
sl
sil
```

```
In [29]: # Well, not perfect, but we see fossil there among other values which are in the dict
        # This is not a bad way to clean up OCR data. It can useful to use a language or doma
        # dictionary in practice, especially if you are generating a search engine for specia
        # such as a medical knowledge base or locations. And if you scroll up and look at the
        # we were working with - this small little wall hanging on the inside of the store -
        # so bad.
        #
        # At this point you've now learned how to manipulate images and convert them into tex
        # next module in this course we're going to dig deeper further into a computer vision
        # which allows us to detect faces among other things. Then, on to the culminating pro
```

0.4 Jupyter Widgets (Optional)

```
In [31]: # In this brief lecture I want to introduce you to one of the more advanced features
        # Jupyter notebook development environment called widgets. Sometimes you want
        # to interact with a function you have created and call it multiple times with differ
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# parameters. For instance, if we wanted to draw a red box around a portion of an
# image to try and fine tune the crop location. Widgets are one way to do this quickl
# in the browser without having to learn how to write a large desktop application.
#
# Lets check it out. First we want to import the Image and ImageDraw classes from the
# PILLOW package
from PIL import Image, ImageDraw

# Then we want to import the interact class from the widgets package
from ipywidgets import interact

# We will use interact to annotate a function. Lets bring in an image that we know we
# are interested in, like the storefront image from a previous lecture
image=Image.open('readonly/storefront.jpg')

# Ok, our setup is done. Now we're going to use the interact decorator to indicate
# that we want to wrap the python function. We do this using the @ sign. This will
# take a set of parameters which are identical to the function to be called. Then Jup
# will draw some sliders on the screen to let us manipulate these values. Decorators,
# which is what the @ sign is describing, are standard python statements and just a
# short hand for functions which wrap other functions. They are a bit advanced though
# we haven't talked about them in this course, and you might just have to have some f
@interact(left=100, top=100, right=200, bottom=200)

# Now we just write the function we had before
def draw_border(left, top, right, bottom):
    img=image.copy()
    drawing_object=ImageDraw.Draw(img)
    drawing_object.rectangle((left,top,right,bottom), fill = None, outline ='red')
    display(img)
```

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interactive(children=(IntSlider(value=100, description='left', max=300, min=-100), IntSlider(va
```

In [32]:
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# Jupyter widgets is certainly advanced territory, but if you would like
# to explore more you can read about what is available here:
# https://ipywidgets.readthedocs.io/en/stable/examples/Using%20Interact.html
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