A1_tdm47_E3

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1 EECS 531 - A1

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1.0.2 Assignment 1

Exercise 3 As with the previous two assignments, this one uses the same imports.

```
In [1]: %matplotlib inline
        import cv2
        import math
        from matplotlib import pyplot as plt
        from matplotlib import patches as patches
        import numpy as np
```

At this point, I define the `correlation` function. This function is the similar to the `convolution` function, with the absense of the initial rotation.

Some changes include:

1. I define the padded image with a white background in order to match the text background.
2. Instead of element-wise matrix multiplication, then summation, I do element-wise matrix subtraction, square each element, then sum.

```
In [2]: def correlation(img, kernel):
            #kernel = np.flip(np.flip(kernel, 1), 0) #flip the kernel on both axis

            width, height, channels = img.shape
            k_width, k_height = kernel.shape

            k_half_width = math.floor(k_width/2)
            k_half_width_2 = math.ceil(k_width/2)
            k_half_height = math.floor(k_height/2)
            k_half_height_2 = math.ceil(k_height/2)

            ret = np.zeros(img.shape)

            img_pad = np.ones((width + k_width + 1 , height + k_width + 1, channels))
            img_pad[k_half_width : -k_half_width_2 - 1,
```

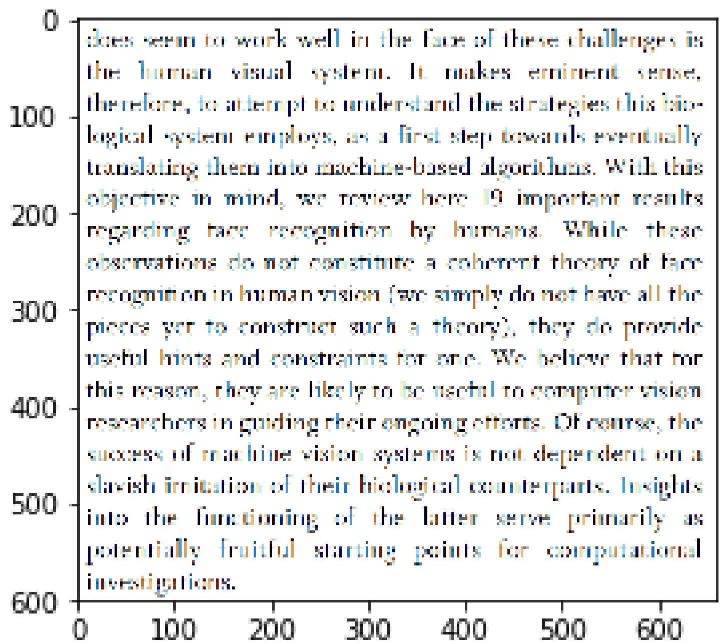
```
                k_half_height : -k_half_height_2 - 1] = img

        for x in range(width):
            for y in range(height):
                for c in range(channels):
                    ret[x, y, c] = np.power(np.subtract(img_pad[x: x + k_width,
                                                                y  : y + k_height,
                                                                c], kernel), 2).sum()
        return ret/ret.max()
```

I now import the image containg the text that I will be attempting to match the letter `h` to. In addition, I normalize the image to range `0. - 1.`.

```
In [3]: img = cv2.imread('./characters.png', 1) #load all three channels, due to rendering pro
        if img is not None:
            b,g,r = cv2.split(img)
            img = cv2.merge((r,g,b))
        img = img/img.max()
```

```
In [4]: plt.imshow(img)
        plt.show()
```



I define a function that will create a square kernel using a given template image. To make a template, I used a screenshot I took of the letter `h`.

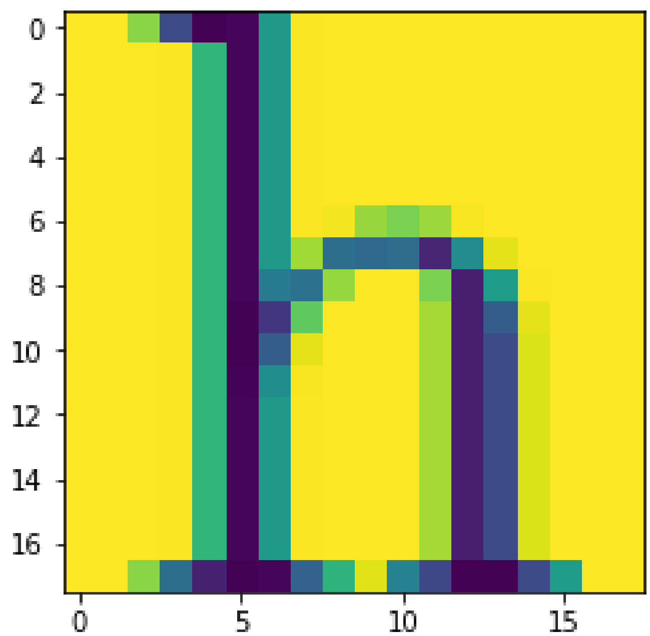
This template was made with a screenshot of the text.

```
In [5]: def create_kernel(img):
            patch = cv2.imread(img, 0)
```

```
    patch = patch/patch.max()
    width, height = patch.shape
    k_size = np.amax(patch.shape)
    ret = np.ones((k_size, k_size))
    x_diff = math.floor((k_size - width)/2)
    y_diff = math.floor((k_size - height)/2)
    ret[x_diff:k_size-x_diff,y_diff:k_size-y_diff] = patch
    return ret
```

Here is how the matching template looks.

```
In [6]: kernel = create_kernel('./h.png')
        plt.imshow(kernel)
        plt.show()
```

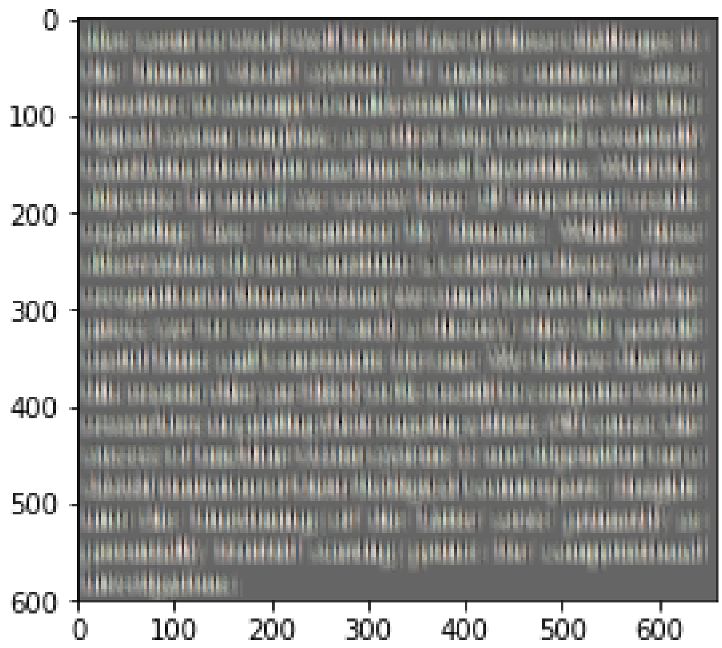


To determine where the h is located, we run the correlation function on the image. As we discussed in class, a lower correlation (not really intuitive based on how I named it) value implies that the template/kernel is more similar to the current pixel location. With this knowledge, we can determine the probability of each part of the image containing the kernel.

```
In [7]: probability = correlation(img, kernel)
```

To see a "heat map" of the likelihood of at `h` at each point, I have displayed the correlation below. It appears to look like a blurred image, but that's due to each letter be somewhat likely of being an h. The most likely spots have the darkest pixels.

```
In [8]: plt.imshow(probability)
        plt.show()
```



To filter the probability map, I set a limit on what classifies as an h. The purpose of this function is to select pixels used for the center of the bounding boxes.

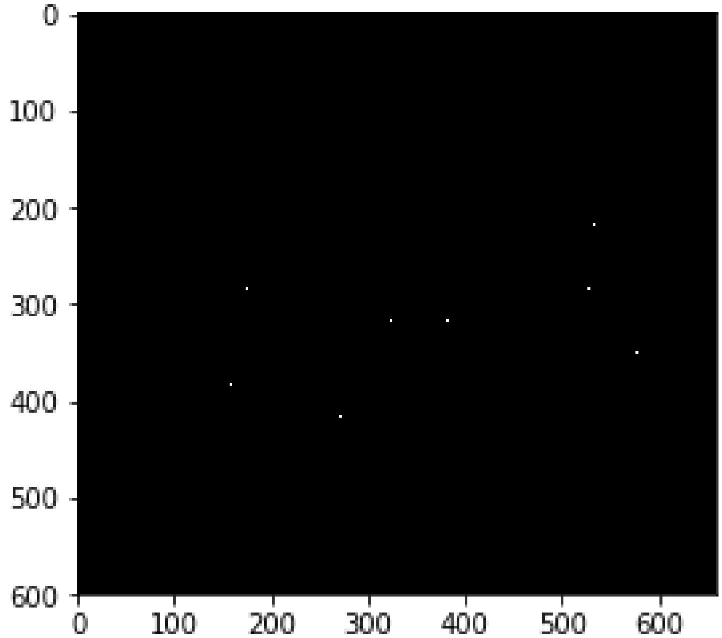
```
In [9]: def threshold(supp, t2):
            ret = np.zeros_like(supp)

            width, height, channels = supp.shape
            k_width, k_height = kernel.shape
            k_half_width = math.ceil(k_width/2)
            k_half_height = math.ceil(k_height/2)

            for x in range(k_half_width,width-k_half_width):
                for y in range(k_half_height,height-k_half_height):
                        theta = np.sum(supp[x, y, :])
                        if theta < t2:
                            ret[x, y, :] = 1.
                        else:
                            ret[x, y, :] = 0.
            return ret
```

I then output a matrix of pixels that pass the threshold and are classified as the letter h. The white dot indicates that the template matching found a high enough correlation at that location.

```
In [10]: heatmap = threshold(probability, 0.075 * 3)
         plt.imshow(heatmap, cmap = "BuPu")
         plt.show()
```

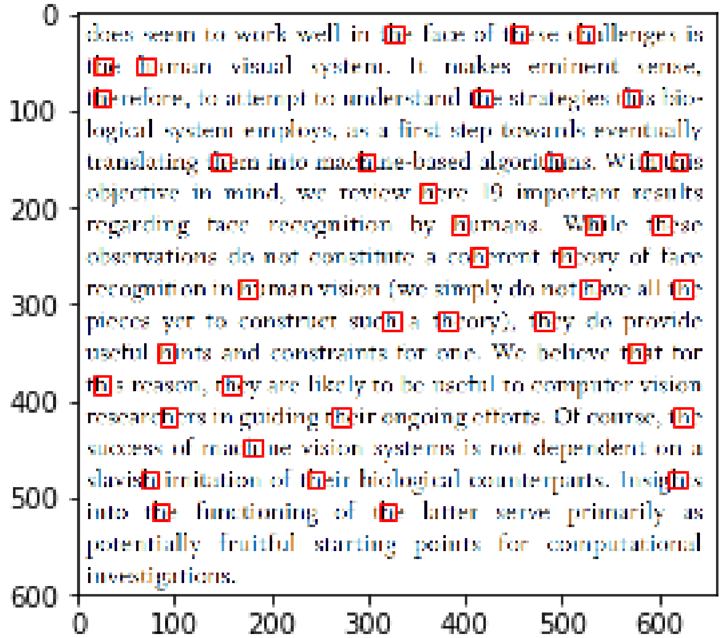


Here, I define a simple function that iterates through the pixels and applys a template sized bounding box at the various locations selected by the previous methods.

```
In [11]: # draw rectangles
         def plot_squares(img, heatmap):
             p_width, p_height, channels = heatmap.shape
             x_offset = math.floor(kernel.shape[0]/2)
             y_offset = math.floor(kernel.shape[1]/2)
             fig,ax = plt.subplots(1)
             ax.imshow(img)
             for x in range(p_width):
                 for y in range(p_height):
                     if heatmap[x, y, 0] == 1.:
                         rect = patches.Rectangle((y - y_offset,x - x_offset),kernel.shape[0],
                         ax.add_patch(rect)
             plt.show()
             fig.savefig("./output.png", dpi=240)  # save the image to the working directory -
```

Here is the output of the matching process, with the selected spots highlighted by red bounding boxes. With a threshold value of 0.08, every `h` is correctly classified. I will explore this relationship in Exercise 4.

```
In [12]: plot_squares(img, heatmap)
         print("Number of detections:",heatmap.sum() / 3) # due to 3 RGB channels
```



Number of detections: 38.0