# Assignment 4

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## 1 Introduction

Template matching is used for many applications in image processing. Cross correlation is the basic statistical approach to image classification. It is used for template matching or pattern recognition. Template can be considered a sub-image from the reference image incandescent illumination.

## 2 Experiment

### 2.1 Part 1

In this assignment, we will use cross correlation to classify images refer to American Sign Language. To implement Image Classification Using Cross Correlation we need to perform 4 steps

Step 1: Cross Correlation Calculation

Calculate the cross correlation for each target image and the template to obtain the offsets and the peak signals.
Step 2. Compare the peak signals

Compare the peak signals for each template.
Step 3. Select the maximum peak

Select the maximum peak with respect to the given template to classify the target image.
Step 4. Classify

Classify the target with respect to the maximum peak of the template.

## 2.2 Approach and Correct Predictions

For the assignment, I approached as follows: First of all, I wrote a function that collects all the images into an array to avoid dealing with images in different target folders. Then I wrote the normalized cross correlation function that we are familiar with. I progressed by keeping the maximum score we achieved for template matching. I've updated here when the new max score comes in. I also kept the coordination of these areas so that I could draw the bounding box. I turned the results into a dataframe and created a confusion matrix. I can say that I repeated the same process for the HOGs part. I have completed the necessary operations using HOG images.

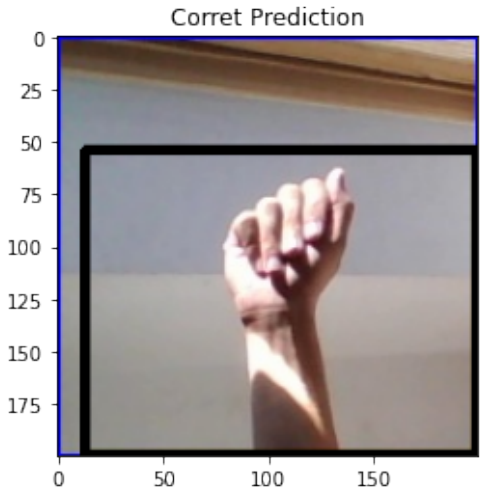


Figure 1: A

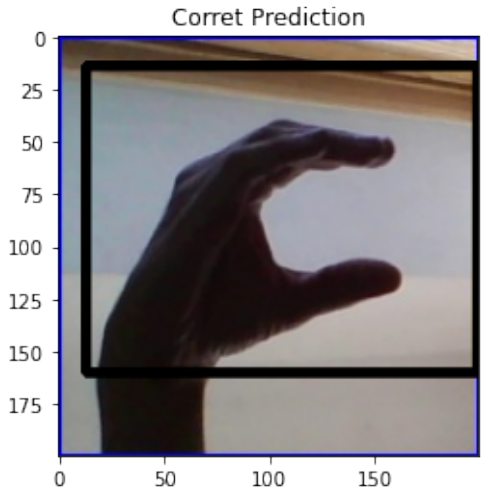


Figure 2: C

Here are 6 images(Two on top, four below) where the algorithm predicted correctly. Most correlated offsets in images looks great. The algorithm was able to accurately detect both bright and dark images. This is because normalized cross correlation is not affected by intensities.

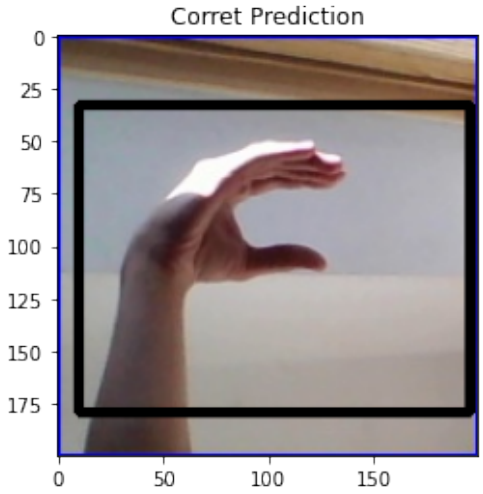


Figure 3: C

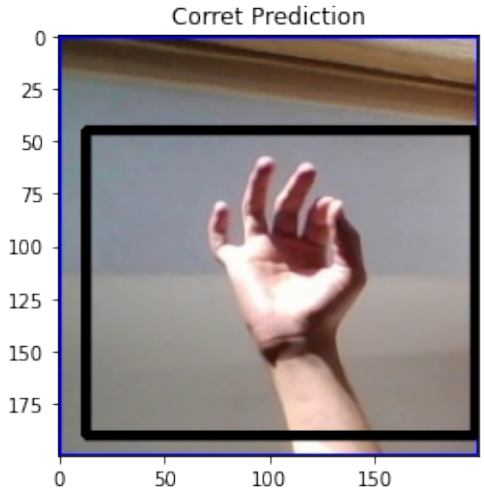


Figure 4: F

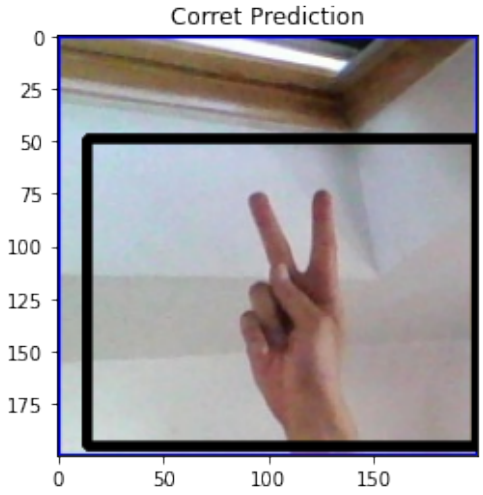


Figure 5: K

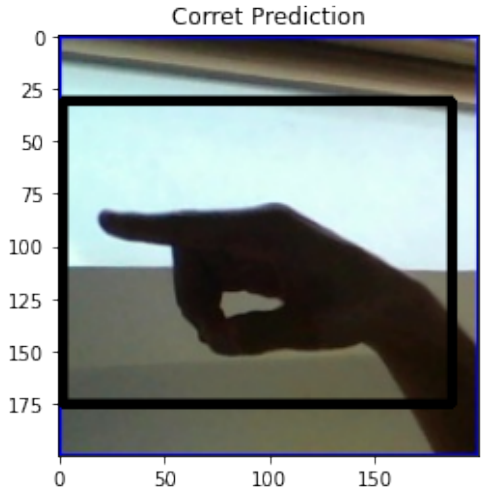


Figure 6: P

### 2.3 Wrong Predictions

As we can see from the images, although the position of the hand is correct in some pictures, the correct letter could not be detected. In some images, the problem is that the position of the hand cannot be found correctly. Naturally, when the position is wrong, it is inevitable that the letter will be wrong.

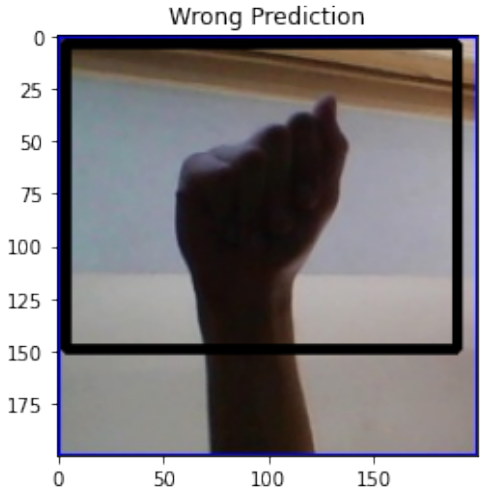


Figure 7: A predicted as Z

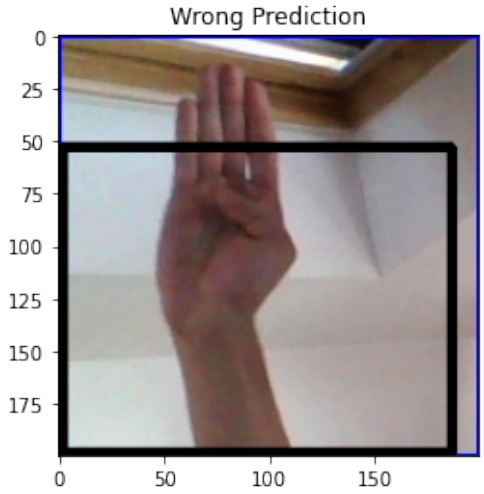


Figure 8: B predicted as E

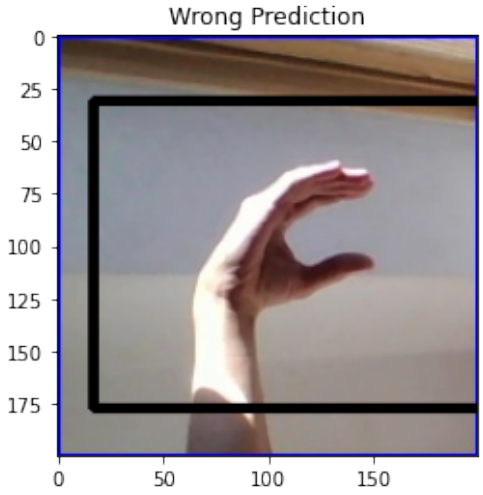


Figure 9: C predicted as D

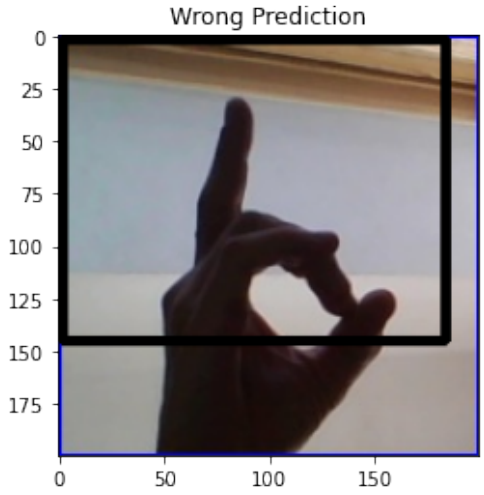


Figure 10: D predicted as L

## 2.4 Confusion Matrix

Algorithm made 77 correct, 703 wrong predictions. This gives us a 9,87 percent accuracy which is pretty low. It's not surprising that the results are so bad. The Object detection problem is quite complex for a simple method like NCC. The algorithm predicted the most successful letters C and J. The letters that caused the most false detections were L and T.

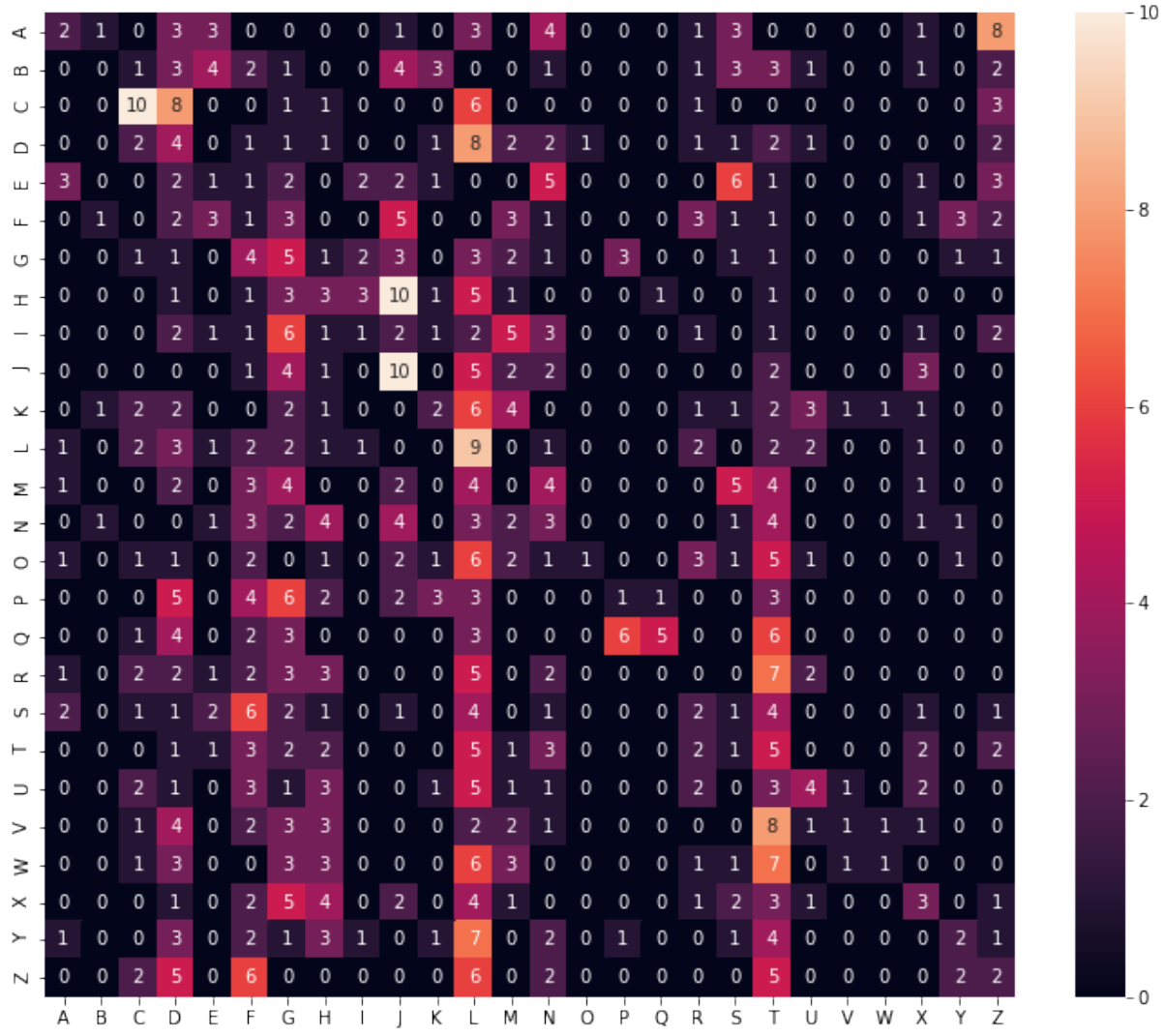


Figure 11: Target Image

## 2.5 Histogram of Oriented Gradients

This time we will do the same operations using histogram of oriented gradients(HOGs). Using HOG algorithm made 37 correct, 743 wrong predictions. HOG affected our results in a bad way. HOG creates edges. We are losing subtle details by using HOG. When we look at the heatmap, we can see something interesting going on. Algorithm made a lot of wrong predictions on Q and T. Also, the algorithm correctly classified 16 out of 30 Q letters.

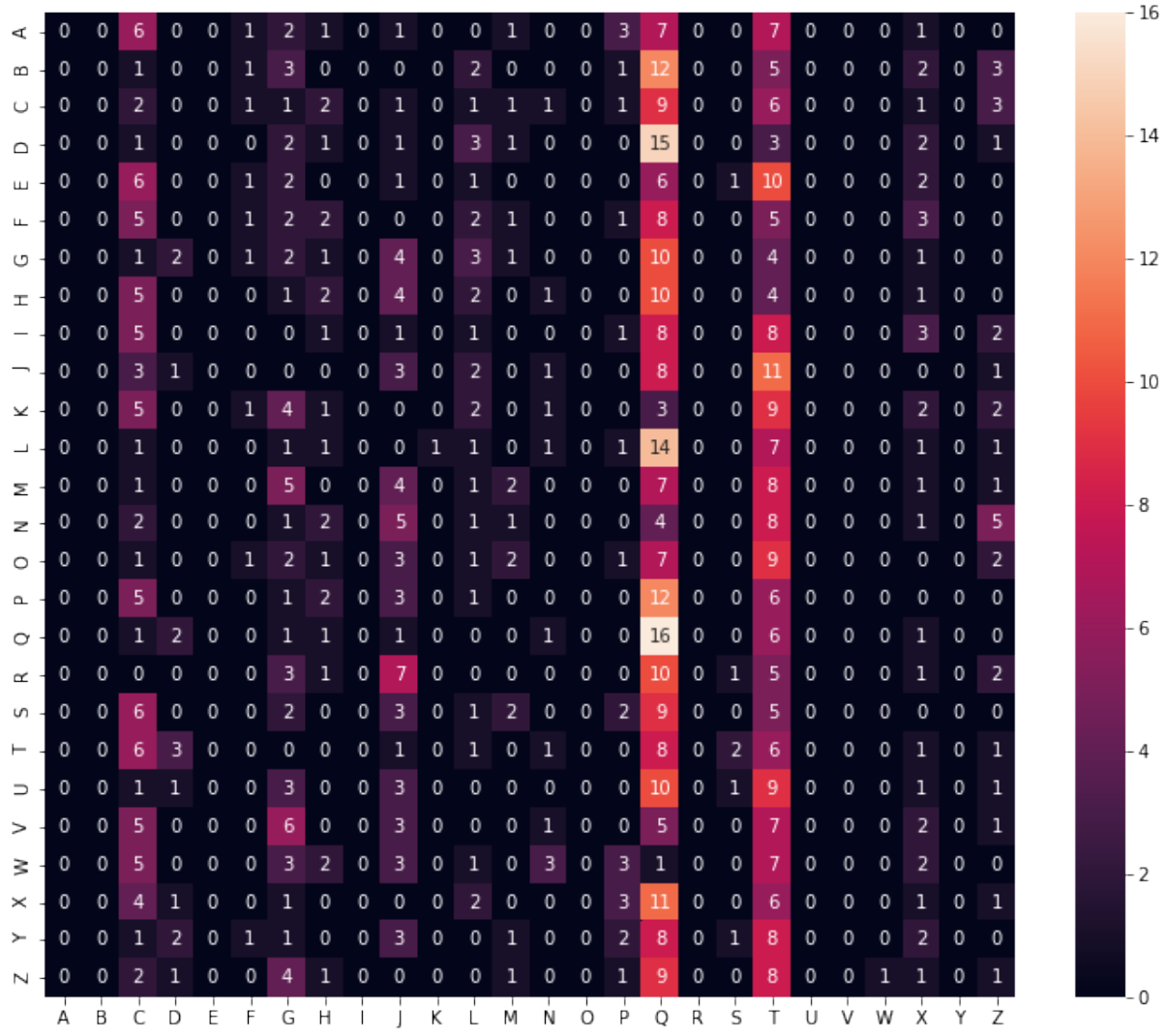


Figure 12: Target Image

Here are 4 images where the algorithm predicted correctly. Most correlated offsets in images looks great. The algorithm was able to accurately detect both bright and dark images.

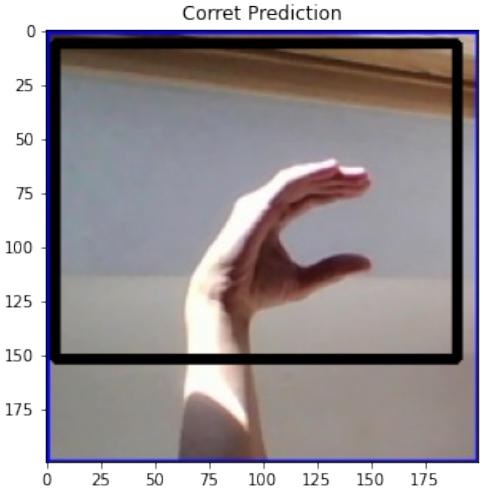


Figure 13: A predicted as Z

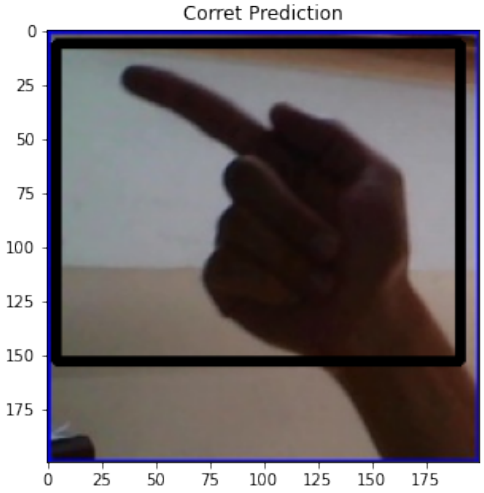


Figure 14: B predicted as E

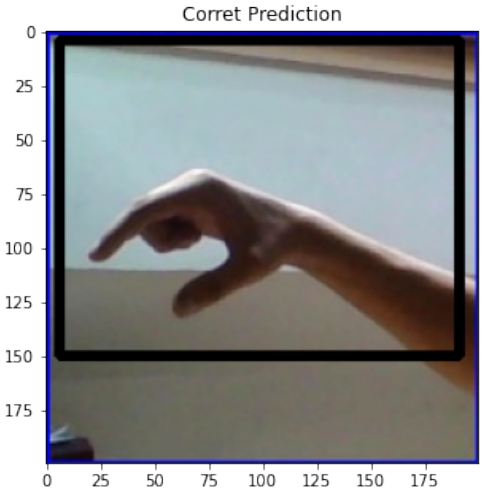


Figure 15: C predicted as D

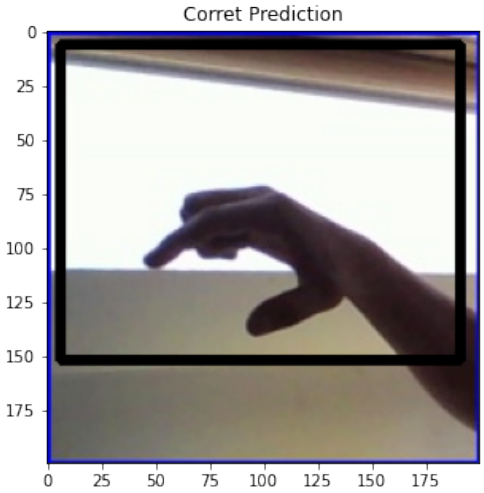


Figure 16: D predicted as L

# 3 Conclusion

In this assignment we perform Image Classification Using Cross Correlation. As we can see from the results we have obtained, we have seen that the NCC method is not suitable for image classification. Although NCC was efficient and fast in template matching on the same image, it was weak in similar images. Subtle changes in details caused NCC not to produce good results. We can achieve better results by using Deep Learning methods in challenging tasks

such as image classification.