AIN432 Assignment4

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1 Introduction

Image classification is a process of assigning a label or class to an image based on its visual content. It is a fundamental task in the field of computer vision and has numerous applications such as object recognition, facial recognition, and scene understanding. One method of performing image classification is through the use of cross-correlation. Cross-correlation is a statistical technique that measures the similarity between two sets of data. In the context of image classification, cross-correlation can be used to compare an image with a set of known class templates and determine which class the image belongs to based on the highest correlation coefficient.In this assignment, the correspondence of the letters corresponding to the images in American Sign Language as a dataset estimated using the cross-correlation method.

2 Overview of the Problem

Image classification is a computer vision task in which an algorithm is trained to assign a label or class to an input image. It is a type of supervised learning, where a model is trained on a labeled dataset and is then able to predict the class of an unseen image. There are a variety of approaches to image classification, including:
1-Traditional machine learning methods such as support vector machines (SVMs) and decision trees.
2-Convolutional neural networks (CNNs), which are particularly effective for image classification tasks due to their ability to learn spatial hierarchies and process images at different scales.
3-Transfer learning, which involves using a pre-trained model on a large dataset and fine-tuning it for a specific classification task.
4-Ensemble methods, which combine the predictions of multiple models to improve the overall accuracy of the classification.
5-Last method that can be used in image classification is normalized cross-correlation. This involves calculating the cross-correlation between the image and a template, and normalizing the result by dividing it by the product of the standard deviations of the image and the template. Normalized cross-correlation can be used to identify patterns or templates in images, and has applications in tasks such as object recognition and facial recognition.

In this assignment, the simplest of these methods, the normalized cross correlation method, was used.

3 Image Classification Using Cross Correlation

3.1 Details of Approach

Normalized cross-correlation is a method for comparing the similarity between an image and a template. It is often used in image processing and computer vision applications to identify patterns or templates within an image.

To perform normalized cross-correlation, the image and template are first convolved, or combined using a mathematical operation called convolution. The convolved result is then normalized by dividing it by the product of the standard deviations of the image and the template. The result of this calculation is a normalized cross-correlation coefficient, which ranges from -1 to 1.

A coefficient of 1 indicates a perfect match between the image and template, while a coefficient of -1 indicates a complete mismatch. A coefficient of 0 indicates that there is no correlation between the image and template.

Normalized cross-correlation can be used in a variety of image processing tasks, such as object recognition, template matching, and facial recognition. It is particularly useful in cases where the image may be rotated, scaled, or otherwise transformed, as the normalization step helps to account for these changes.

3.2 Application Steps of Image Classification Using Cross Correlation

Normalized cross-correlation can be used as a method for image classification in the following steps:

1- Preprocessing: The image and template may need to be preprocessed before performing normalized cross-correlation. This may include steps such as resizing, cropping, or smoothing the image to remove noise.

2- Convolution: The image and template are convolved, or combined using a mathematical operation called convolution. This produces a convolved result, which is a measure of the similarity between the image and template.In the target image, the region most similar to the template image (the highest normalized cross correlation value) is selected.

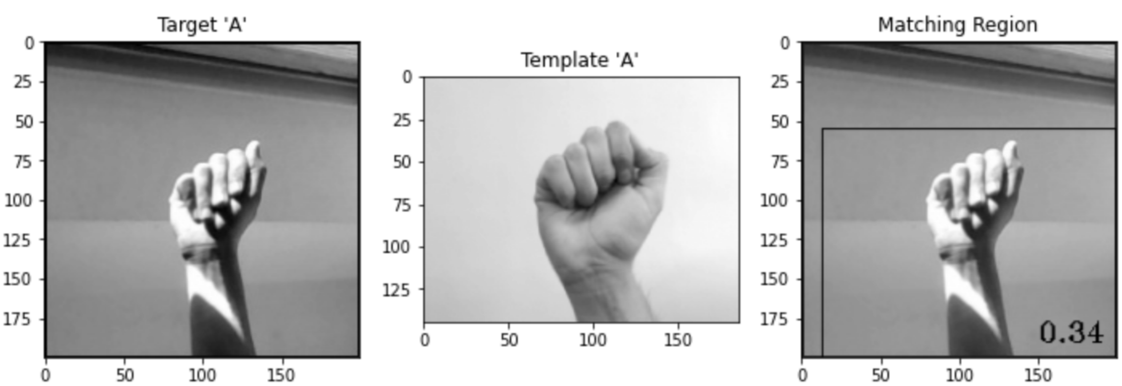
3- Normalization: The convolved result is normalized by dividing it by the product of the standard deviations of the image and the template. This produces a normalized cross-correlation coefficient, which ranges from -1 to 1.

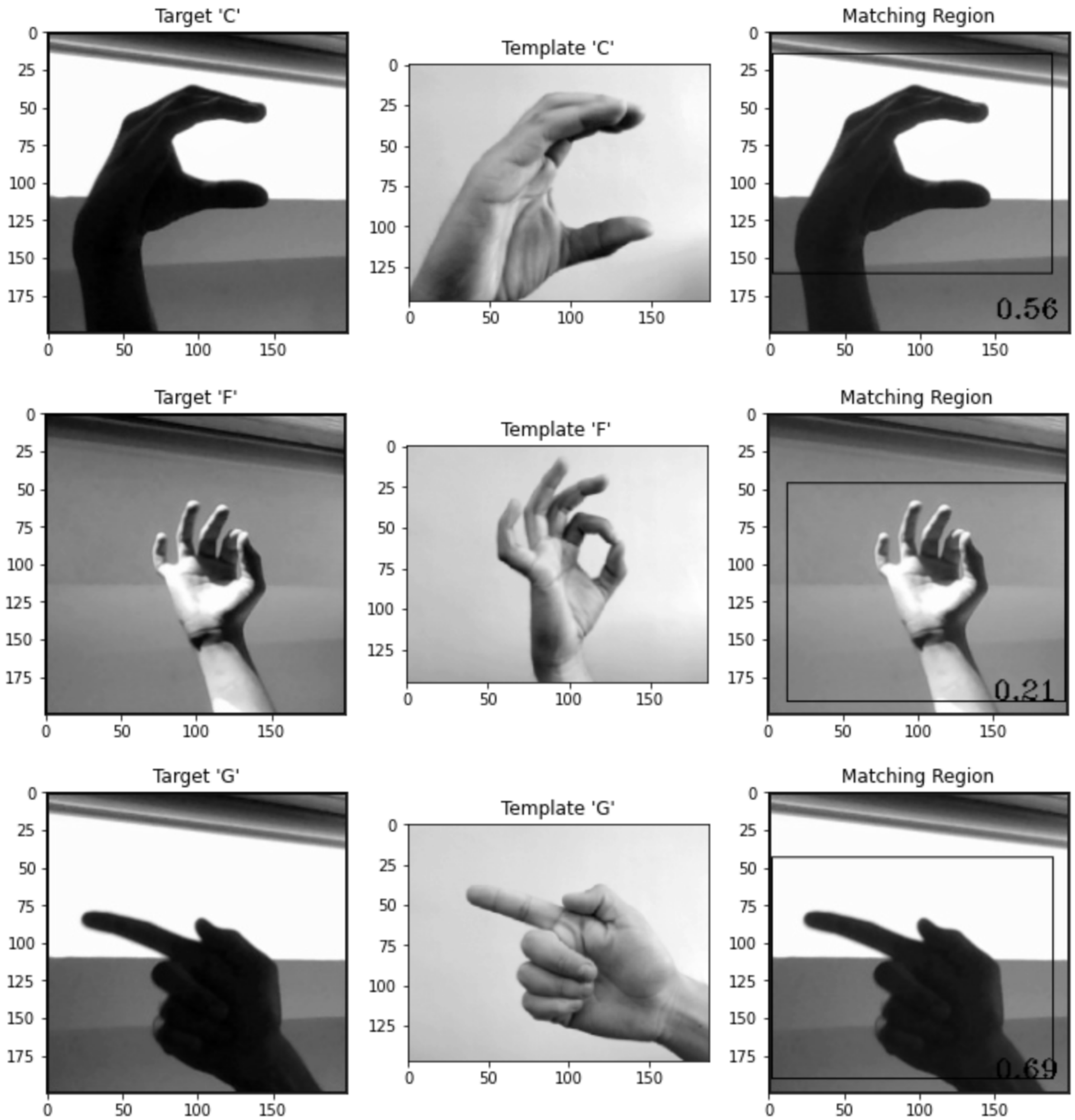
4- Classification: The highest value (closest to 1) is selected between the calculated normalized cross correlation values of the target image and the template images, and that class tag is given to the target image.

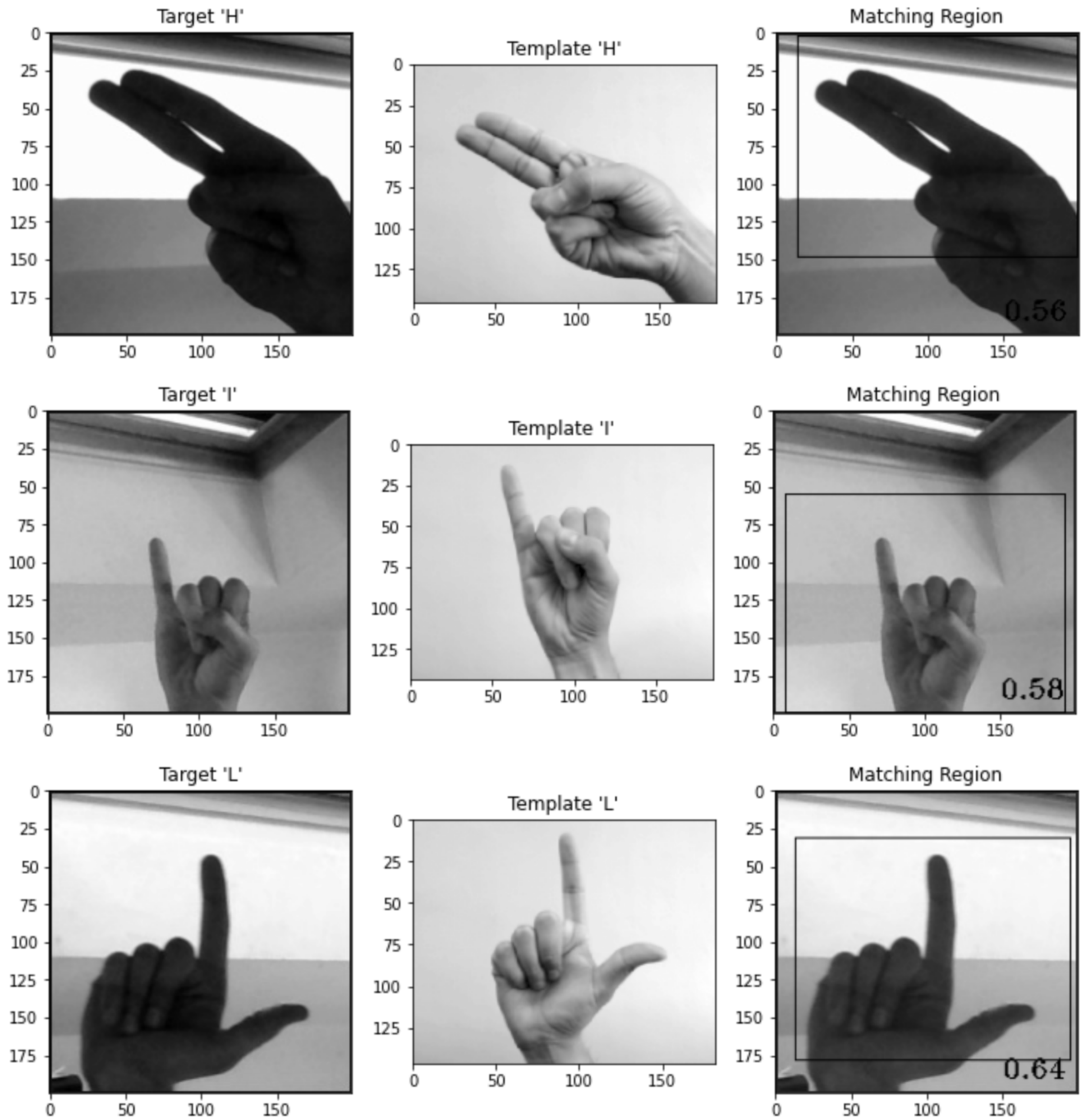
5- Evaluation: The accuracy value is calculated between the real classes of the target images and the classes calculated by the model. According to the result, the success of the model is measured.

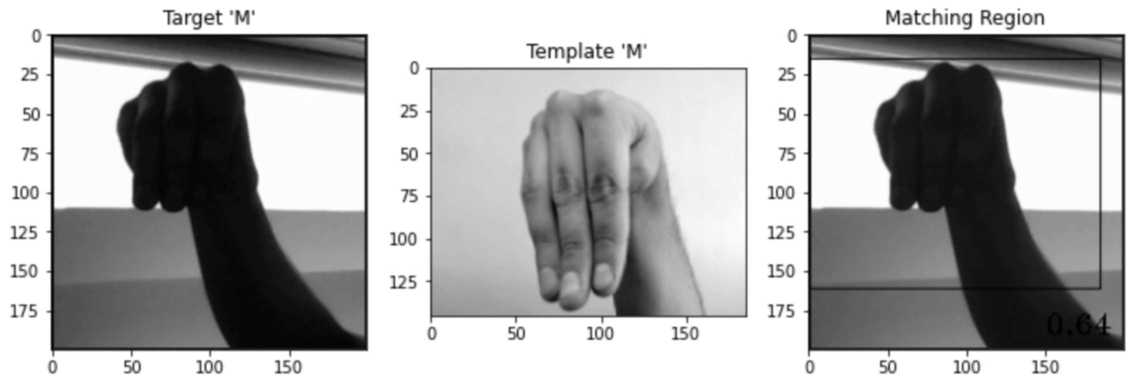
3.3 Discuss Result Images

Good Result

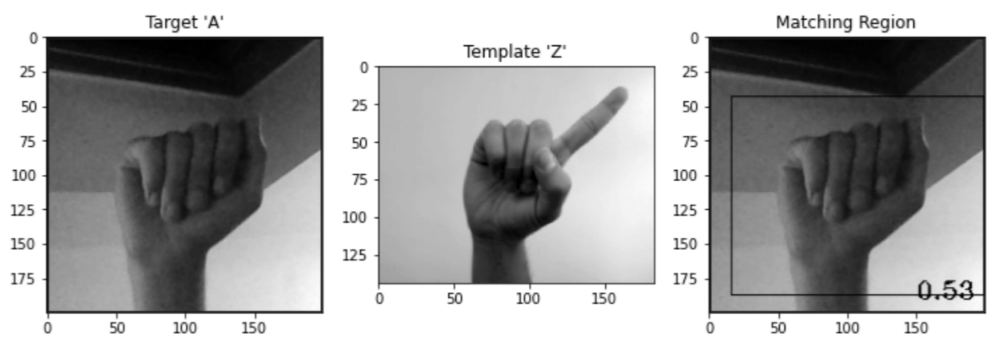


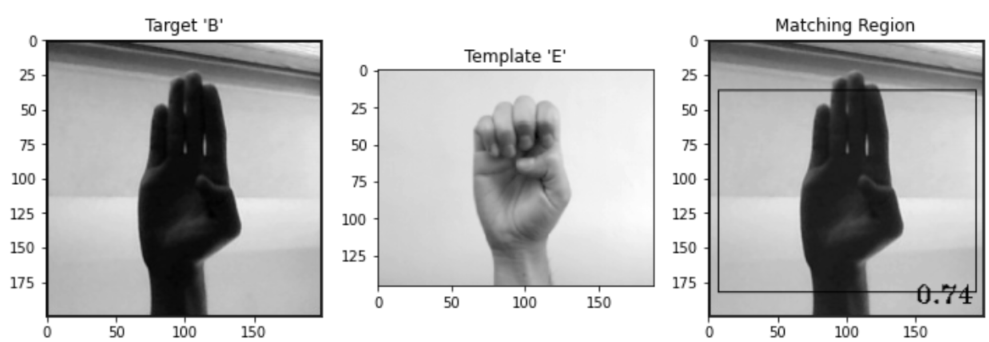

Target 'C'
Template 'C'
Matching Region
0.56
Target 'F'
Template 'F'
Matching Region
0.21
Target 'G'
Template 'G'
Matching Region
0.69

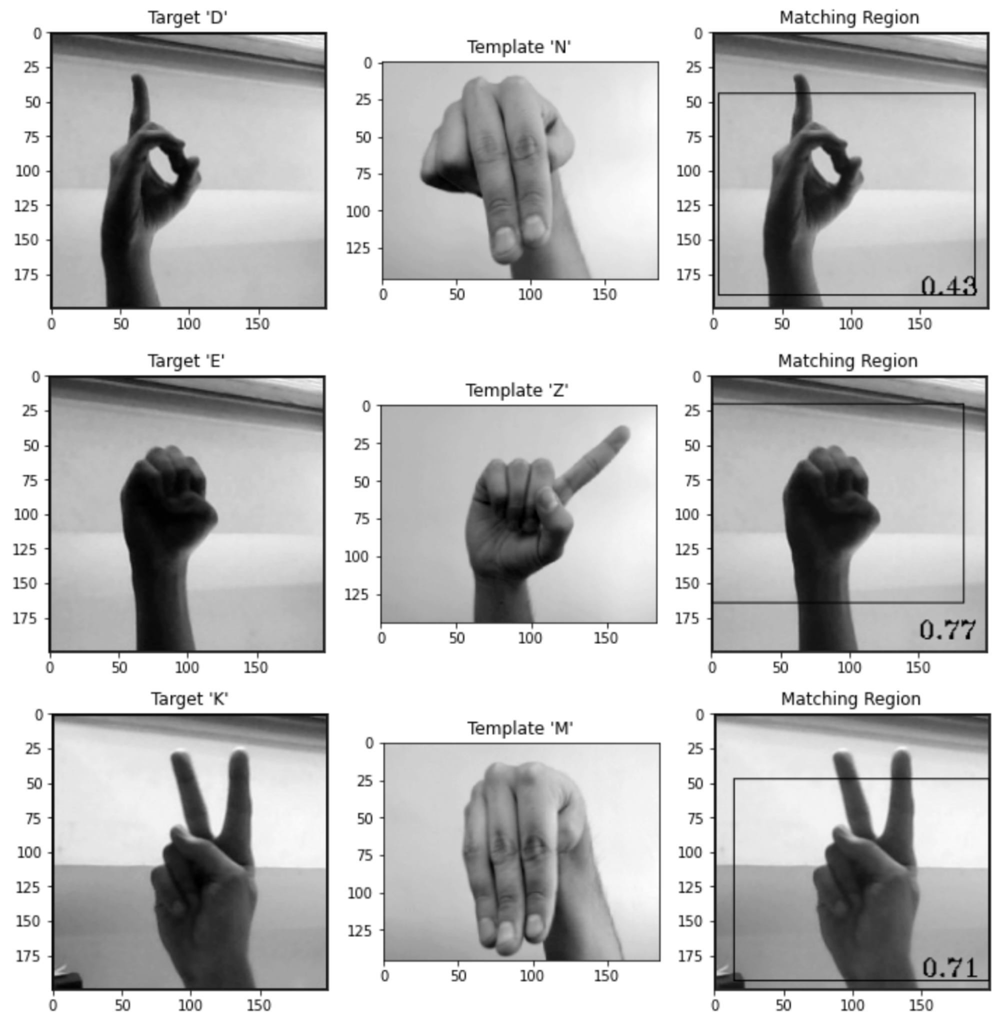

Target 'H'
Template 'H'
Matching Region
0.56
Target 'I'
Template 'I'
Matching Region
0.58
Target 'L'
Template 'L'
Matching Region
0.64


Target 'M'
Template 'M'
Matching Region
0.64

Bad Result


Target 'A'
Template 'Z'
Matching Region
0.53


Target 'B'
Template 'E'
Matching Region
0.74



Normalized cross-correlation (NCC) is a measure of the similarity between two image patches. It is often used in image classification to determine the degree to which a given image patch matches a known template. Here are some potential positive and negative sides of using NCC for image classification:

Positive:

NCC is relatively simple to compute and understand, making it easy to implement and interpret.
NCC is invariant to brightness and contrast changes, meaning it can still accurately match image patches even if the overall brightness or contrast of an image has changed.

NCC is rotationally invariant, meaning it can still accurately match image patches even if one of the patches has been rotated.

Negative:

NCC can be sensitive to noise, meaning that small variations in pixel values due to noise can affect the correlation score. This can make NCC less reliable when working with images that have a lot of noise.
NCC may not be as effective as other methods for matching image patches that have undergone more significant deformations, such as scaling or shearing.
NCC is sensitive to the choice of template, so it is important to carefully select a good template in order to get accurate results.

Theoretically, the positive and negative features of the NCC method are given above. I think the reason for the bad results in our assignment is the noise and the different size of the regions where the images are likely to match.Also, when I classified the dataset in this assignment with the NCC method, I got a very low accuracy value of 11%. I think the NCC method is not suitable for classification. It also proves that it works very slow even though it is 1k images.

4 Conclusion

In conclusion, normalized cross-correlation is a useful method for comparing the similarity between an image and a template in image processing and computer vision applications. It involves convolving the image and template and normalizing the result to produce a normalized cross-correlation coefficient. This coefficient can be used to determine whether the image and template match, with a coefficient above a certain threshold indicating a match and a coefficient below the threshold indicating a non-match. Normalized cross-correlation can be used in a variety of image classification tasks, including object recognition, template matching, and facial recognition. It is particularly useful in cases where the image may be rotated, scaled, or otherwise transformed, as the normalization step helps to account for these changes.