Hacettepe University

Computer Engineering Department

BBM415 – Fundamentals of Image Processing Lab.

Assignment 4 Report

Image Classification Using Cross Correlation

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For this problem, we need to classify some images using cross correlation technique. These images are some different versions of letters in American Sign Language. Some of them are dark, some are not centered, some are blurry etc.

We also have template images for American Sign Language that are properly given.

We need to match target images to template images to do classification. In order to match these images, we need to use Normalized Cross Correlation (NCC).

Product of the variations of intensities from mean in template and image

$$\rho_{12}(u, v) = \frac{\sigma_{g_1 g_2}(u, v)}{\sigma_{g_1}(u, v)\sigma_{g_2}}$$

Standard deviation of intensity values of the image in the area overlayed by template

Standard deviation of intensity values of the template

The program slides template image over target image and calculates NCC value for every offset (u, v). Then it selects the highest NCC value for that template image.
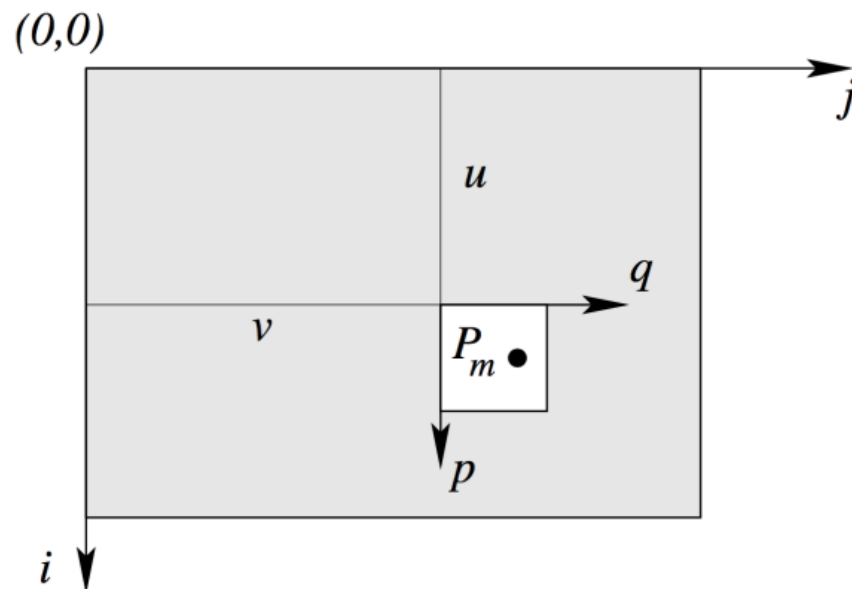
After doing same steps for every template image, program selects a template image which has highest NCC value among all template images and matches this template with target image.

Since we're working with just values of pixels, our program can't classify all target images correctly, so we need to calculate accuracy of our classification method.

Program's accuracy values are like that.

```
        3 / 30
        Accuracy of target images H is: %10.0

1 / 30
Accuracy of target images I is: %3.3333333333333335

11 / 30
Accuracy of target images J is: %36.666666666666664

        0 / 30
        Accuracy of target images K is: %0.0

        9 / 30
        Accuracy of target images L is: %30.0

5 / 30
Accuracy of target images M is: %16.666666666666664

        3 / 30
        Accuracy of target images N is: %10.0

        0 / 30
        Accuracy of target images O is: %0.0

        6 / 30
        Accuracy of target images P is: %20.0

 10 / 30
 Accuracy of target images Q is: %33.33333333333333

1 / 30
Accuracy of target images R is: %3.3333333333333335

1 / 30
Accuracy of target images S is: %3.3333333333333335

1 / 30
Accuracy of target images T is: %3.3333333333333335

        3 / 30
        Accuracy of target images U is: %10.0

1 / 30
Accuracy of target images V is: %3.3333333333333335

1 / 30
Accuracy of target images W is: %3.3333333333333335

1 / 30
Accuracy of target images X is: %3.3333333333333335
```

```
0 / 30
Accuracy of target images Y is: %0.0
```

```
4 / 30
Accuracy of target images Z is: %13.333333333333334
```
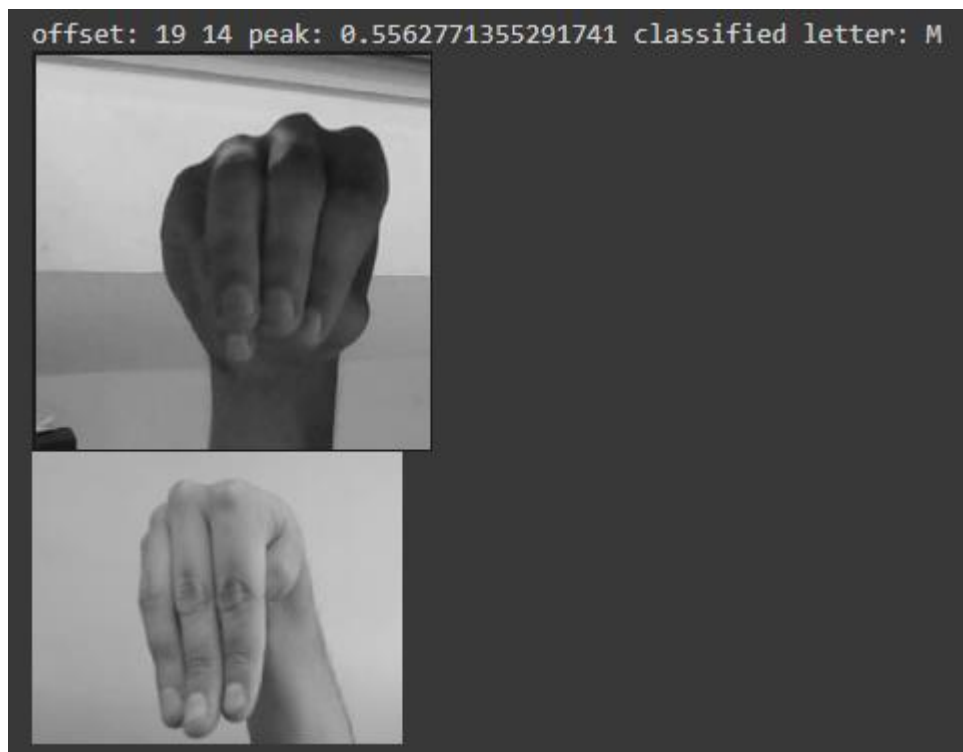
Total Accuracy

```
87 / 780
Total accuracy is: %11.153846153846155
```

Program's results are like that.

1- Correct classification of target C.

2- Correct classification of target M.

offset: 19 14 peak: 0.5562771355291741 classified letter: M

3- Misclassification of target A with template S.

(Very similar hand signs, only thumbs are changing)

offset: 6 15 peak: 0.5816430772435203 classified letter: S

4- Correct classification of target R.

offset: 54 9 peak: 0.5006009431556983 classified letter: R

5- Correct classification of target F.

46 13 0.2050789672138814 5
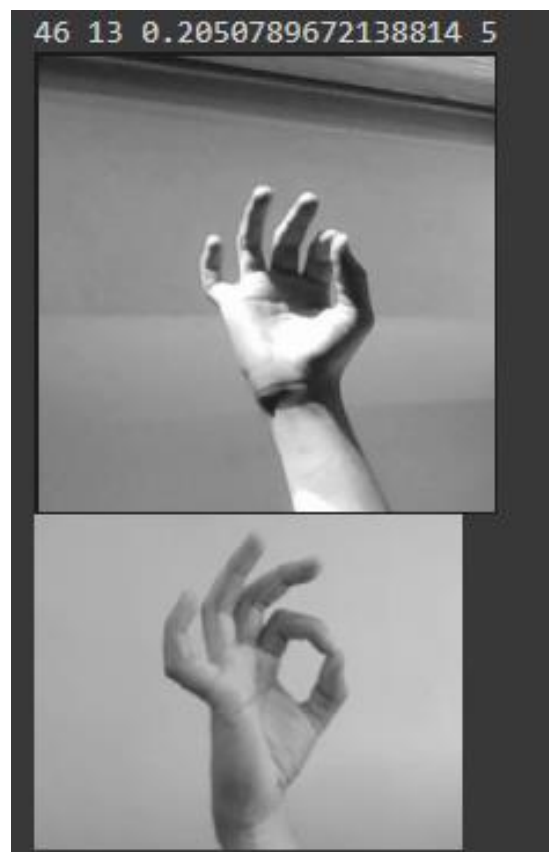
6- Misclassification of target T with template J.

(Not very similar ones, program just miscalculated. NCC peak is low.)

offset: 14 43 peak: 0.2290041418216598 classified letter: J

7- Correct classification of target U.

offset: 24 8 peak: 0.6682897302871953 classified letter: U

8- Correct classification of target Z.

9- Misclassification of target I with template G.
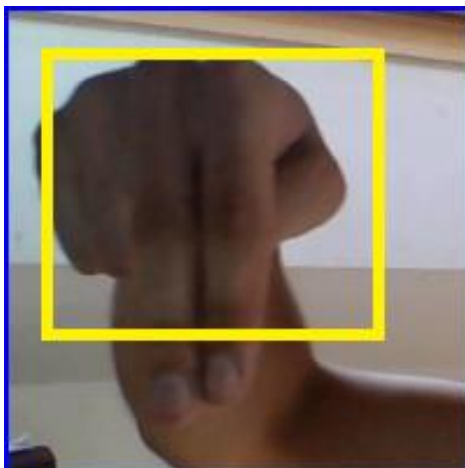
(Hand positions are similar, just a finger changes.)

10-   Correct classification of target P.

offset: 55 7 peak: 0.5838280661687325 classified letter: P

Most corrolated regions with respect to the template are like that.

1- Letter "N" for offset u = 8, v = 6

offset: 8 6 peak: 0.6795722102921992 classified letter: N

2- Letter "V" for offset u = 27, v = 7

offset: 27 7 peak: 0.6373959756101389 classified letter: V

3- Letter "L" for offset u = 52, v = 17

offset: 52 17 peak: 0.6623367004240184 classified letter: L
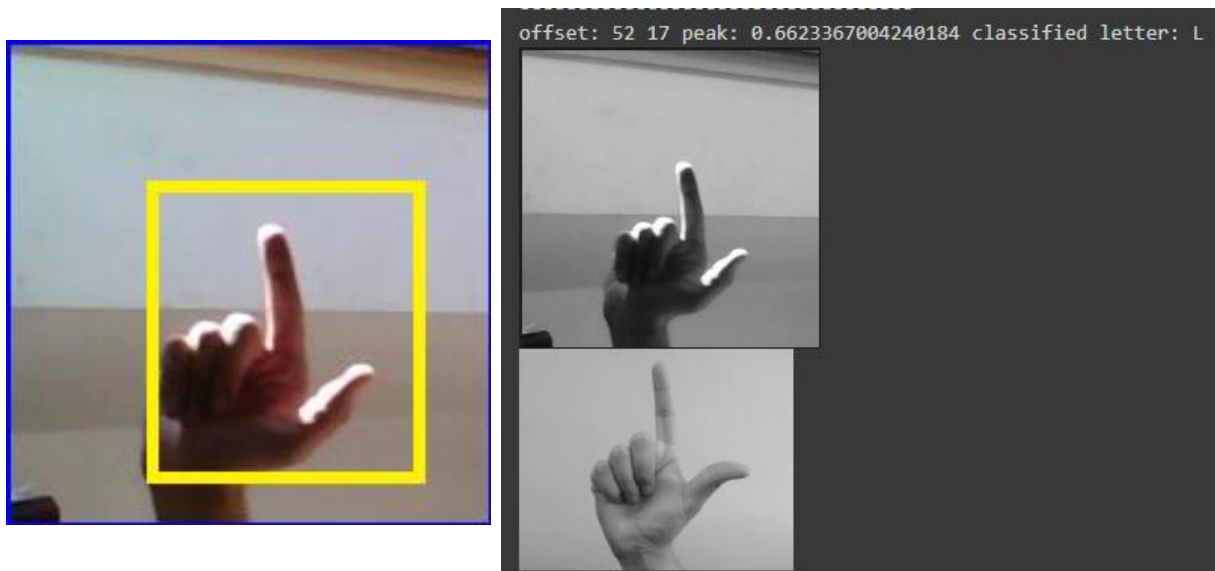
4- Letter "W" for offset u = 20, v = 17

5- Letter "Q" for offset u = 44, v = 14

References:

[1] https://www.ipb.uni-bonn.de/html/teaching/photo12-2021/2021-pho1-09-matching-cc.pptx.pdf

[2] https://towardsdatascience.com/confusion-matrix-for-your-multi-class-machine-learning-model-ff9aa3bf7826