BBM 415 - Image Processing Laboratory

HACETTEPE UNIVERSITY
Department of Artificial Intelligence Engineering

Programming Assignment 4
Fall 2022-2023
Assoc. Prof. Dr. Aydın Kaya

Due Date: 23:59 pm on Thursday, January 5th, 2022

Image Classification Using Cross Correlation

Background

Cross correlation is used in signal processing to obtain the measurement of similarity between two signals by implementing dot product in a sliding window [1]. As images (grayscale) are two dimensional signals, cross correlation can be used in images for template matching given in formula below:

$$F \circ I(x,y) = \sum_{j=-N}^{N} \sum_{i=-N}^{N} F(i,j)I(x+i,y+j) \quad [3]. \quad (1)$$

where F is the filter or template image and I is the target image. The peak given in $[\hat{u},\hat{v}]$ over the target image refers to maximum value of the cross correlation coefficient ρ at that offset [4]:

$$[\hat{u},\hat{v}] = argmax_{u,v}\rho_{12}(u,v) \quad (2)$$

where ρ_{12} is

$$\rho_{12}(u,v) = \frac{\sigma_{IF}(u,v)}{\sigma_I(u,v)\sigma_F} \quad (3)$$

Here, σ refers to standard deviation.

Overview

In this assignment, you will use cross correlation to classify images refer to American Sign Language. For this purpose you must carry out the following steps:

- Calculate the cross correlation
  You will calculate the cross correlation for each target image and the template to obtain the offsets and the peak signals.
- Compare the peak signals
  You will compare the peak signals for each template.
- Choose the maximum peak
  You will choose the maximum peak with respect to the given template to classify the target image.
- Classify
  You will classify the target with respect to the maximum peak of the template.

Figure 1: American Sign Language [2]

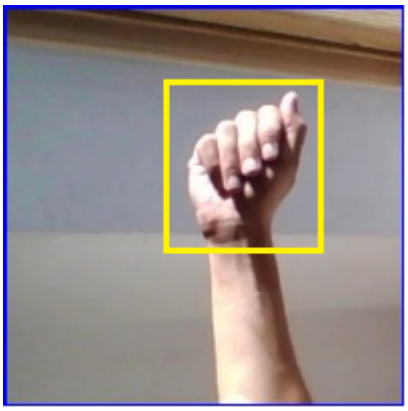

Figure 2: The most correlated region with respect to the template.

Details

Your Python program will take target image and the templates to implement cross correlation for detecting the class of the target.

- You must implement your normalized cross correlation method.
- You must classify all the images given in dataset uploaded in resources of Piazza.
- You must calculate the accuracy of your implementation using confusion matrix.
- You must show the most correlated offsets in a region for at least 5 target images with like given in figure 2.
- You must comment your failed results.
- In addition, you must convert the target and template images to binary images and compute HOGs (histogram of oriented gradients) of the target and template images and make comparisons by using these HOGs.

The Report

Your report should contain a brief overview of the problem, the details of your approach, and the results of your algorithm on at least 10 images with your comments. Show the results of all of the main steps. If your algorithm failed to give a satisfactory result on a particular image, provide a brief explanation of the reason(s).

What to Hand In

Your submission format will be:

- README.txt *(give a text file containing the details about your implementation, how to run your code, the organization of your code, functions etc.)*
- code/ *(directory containing all your code)*
- report.pdf *(PDF report - LaTeX)*

Archieve this folder as **b<studentNumber>.zip** and submit to `https://submit.cs.hacettepe.edu.tr`.

Grading

The assignment will be graded out of 100:

- CODE: 0 (no implementation), 40 (a partial solution), 60 (a correct solution) and REPORT : 40

Academic Integrity

All work on assignments must be done individually unless stated otherwise. You are encouraged to discuss with your classmates about the given assignments, but these discussions should be carried out in an abstract way. That is, discussions related to a particular solution to a specific problem (either in actual code or in the pseudocode) will not be tolerated. In short, turning in someone else's work, in whole or in part, as your own will be considered as a violation of academic integrity. Please note that the former condition also holds for the material found on the web as everything on the web has been written by someone else.

References

[1] https://en.wikipedia.org/wiki/Cross-correlation
[2] https://ieee-dataport.org/open-access/transfer-learning-cnn-american-sign-language
[3] Correlation and Convolution by David Jacobs, 2005, https://www.cs.umd.edu/~djacobs/CMSC426/Convolution.pdf
[4] https://www.ipb.uni-bonn.de/html/teaching/photo12-2021/2021-pho1-09-matching-cc.pptx.pdf