CENG483-THE1

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Introduction

This document is a report for the first assignment of CENG483:Introduction to Computer Vision course. There are 5 main questions which are related with instance recognition with use of various types of histograms.

Note that **TA** is used as an abbreviation for *Top-1 Accuracy*, and **N** is used for *Number Of Bins*, **3D** is used for *3D Histograms*, and **PC** is used for *Per Channel* in this document.

1 Question 1: 3D Color Histogram

1.1 Results of Query Set 1

1. For N=16, TA = 1
2. For N=8, TA = 1
3. For N=4, TA = 1
4. For N=2, TA = 0.96

- As N decreases, TA tends not to change, but after all, it decreases

1.2 Results of Query Set 2

1. For N=16, TA = 1
2. For N=8, TA = 1
3. For N=4, TA = 1
4. For N=2, TA = 1

- As N decreases, there is no change in TA.

1.3 Results of Query Set 3

1. For N=16, TA = 0.11
2. For N=8, TA = 0.105
3. For N=4, TA = 0.115
4. For N=2, TA = 0.075

- As N decreases, TA does not change so much, but when N is 2, TA decreases significantly.

1.4 Comments

Observing the query images by eye,

- Query 1 is nearly the same with support images (in terms of orientation, intensity values per each pixel), so there is no precise change at first look. But if we look and zoom into the images, we can see that there are slight differences around the edges. Maybe some averaging filter is applied on query 1 images.
- Query 2 is a rotated version of support images.
- Query 3 has nearly identical images but different contrast and intensity levels.

Since the intensity values will not change in an enormous range, rotating and applying an averaging filter to an image does not change the color histogram excessively for query 1 & query2.

However, since the histogram is calculated through the intensity values of the color channels, there should be a notable change in the histogram of query 3. Because the intensity and contrast values of query 3 are way more different from support images

2 Question 2: Per Channel Color Histogram

2.1 Results of Query Set 1

1. For N=32, TA = 0.945
2. For N=16, TA = 0.95
3. For N=8, TA = 0.965
4. For N=4, TA = 0.92
5. For N=2, TA = 0.59

- As N decreases, TA tends not to change, but after all, it decreases.

2.2 Results of Query Set 2

1. For N=32, TA = 1
2. For N=16, TA = 1
3. For N=8, TA = 1
4. For N=4, TA = 1
5. For N=2, TA = 1

- As N decreases, there is no change in TA.

2.3 Results of Query Set 3

1. For N=32, TA = 0.135
2. For N=16, TA = 0.13
3. For N=8, TA = 0.145
4. For N=4, TA = 0.145
5. For N=2, TA = 0.04

- As N decreases, TA does not change so much, but when N is 2, TA decreases significantly.

2.4 Comments

The behavior of TA values is just like in 3D histogram case. All TA values **except Query 1, N = 2** case, are close to each other(with an error margin 0.05). Therefore behaviors of TAs due to number of bins are mostly the same between 3D and PC histograms.

Note that, in the following questions N = 4 for 3D Histograms and N = 8 for Per Channel Histograms

3 Question 3: Grid Based Feature Extraction - Query set 1

3.1 2x2 Spatial Grid

- For 3D histogram, TA = 0.945
- For PC histogram, TA = 0.98

3.2 4x4 Spatial Grid

- For 3D histogram, TA = 0.78
- For PC histogram, TA = 1.0

3.3 6x6 Spatial Grid

- For 3D histogram, TA = 0.69
- For PC histogram, TA = 1.0

3.4 8x8 Spatial Grid

- For 3D histogram, TA = 0.655
- For PC histogram, TA = 1.0

3.5 Questions

1. Since the query 1 images are nearly the same as the support images, the results of PC histograms are not affected by dividing them into grids. However, the difference that comes along with the filtering can be seen in 3D histograms as the grid size increases.

2. As the grid size increases, TA of PC increases. However, TA of 3D decreases. Therefore, using PC with grid gives more accurate results **in cases of comparing similar intensity valued images**. On the other hand, using 3D without a grid gives more accurate results.

4 Question 4: Grid Based Feature Extraction - Query set 2

4.1 2x2 Spatial Grid

- For 3D histogram, TA = 0.985
- For PC histogram, TA = 0.42

4.2 4x4 Spatial Grid

- For 3D histogram, TA = 0.92
- For PC histogram, TA = 0.345

4.3 6x6 Spatial Grid

- For 3D histogram, TA = 0.835
- For PC histogram, TA = 0.295

4.4 8x8 Spatial Grid

- For 3D histogram, TA = 0.785
- For PC histogram, TA = 0.245

4.5 Questions

1. Although the images are same (but have different rotations), the corresponding grid levels does not represent the same parts of the images. The results of PC histograms significantly affected by dividing them into grids. Furthermore, increasing the grid size is generating more and more dissimilarities between the images.

   On the other hand, as the grid size increases, the TA of 3D histogram increases.

2. As the grid size increases, TA of PC decreases, and TA of 3D decreases.However, using 3D instead of PC gives more accurate results **in cases of comparing images that are same but have different rotations**.

5 Question 5: Grid Based Feature Extraction - Query set 3

5.1 2x2 Spatial Grid

- For 3D histogram, TA = 0.12
- For PC histogram, TA = 0.255

5.2 4x4 Spatial Grid

- For 3D histogram, TA = 0.09
- For PC histogram, TA = 0.35

5.3 6x6 Spatial Grid

- For 3D histogram, TA = 0.08
- For PC histogram, TA = 0.39

5.4 8x8 Spatial Grid

- For 3D histogram, TA = 0.075
- For PC histogram, TA = 0.435

1. In query 3, the images are the same but have different contrast and intensity values. Since the intensity values are different, and the color histograms store the color values of the images, it is evident that there would be fewer similarities between images in such cases. However, the TA increases as the grid size increases.

   On the other hand, as the grid size increases, the TA of 3D histogram decreases. The reason of low TA is same as for PC.

2. Hence, it is mostly disadvantageous using color histograms **in cases of comparing images that have different contrast and intensity values**.

6 Additional Comments and References

- For matrix operations and histogram representations, *numpy* library is used.
- *OpenCV-python* library used for converting image to a numpy array.
- *Filtering* and *broadcasting* methods of *numpy* is used instead of basic for loops.
- A caching mechanism is used with use of a hash-map which is a regular dictionary.
  - One of the dynamic programming methods, namely *memoization*, is used.
  - *Memoization* occurs at each histogram calculation.
- In calculation of 3D histograms, a base-3 based indexing logic is used.
- L1 normalization implemented without any libraries.