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# CENG 483

## Introduction to Computer Vision

Fall 2021-2022

### Take Home Exam 1

#### Instance Recognition with Color Histograms

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## 1 3D Color Histogram

Query	Interval	Top-1 Accuracy
Query 1	16	1.0
	32	1.0
	64	1.0
	128	1.0
Query 2	16	1.0
	32	1.0
	64	1.0
	128	1.0
Query 3	16	0.11
	32	0.105
	64	0.105
	128	0.105

Table 1: Top-1 accuracy results for each query set with 3D color histogram

I used 96 as grid size (One grid, equivalently no grid at all). Query set 2 images are rotated versions of support images. Therefore, their color distribution is the same. Query set 1 is zoomed version of support images. Query set 3 images are color filtered, having a further color spectrum to the ground truth compared to query set 1. Therefore query set 1's corresponding images have closer distributions, hence more similar results. Furthermore, please note that the applied affine transformation in query set 2 is rotation of multiples of 90 degrees, and the images are square, hence the image also fits in 96x96 grid, contributing to the preservation of the histogram.

## 2 Per Channel Color histogram

Query	Interval	Top-1 Accuracy
Query 1	8	0.98
	16	0.98
	32	0.98
	64	0.98
	128	0.98
Query 2	8	1.0
	16	1.0
	32	1.0
	64	1.0
	128	1.0
Query 3	8	0.125
	16	0.125
	32	0.125
	64	0.125
	128	0.125

Table 2: Top-1 accuracy results for each query set with per-channel color histogram

I used 96 as grid size as in the previous section. Applying color filter modifies the color spectrum more than the channel spectrum. Maybe only one channel is filtered whereas others remain the same. Therefore, query set 3 give better results compared to 3D color histogram.

Similarly to 3D color histogram, query set 2's channel distribution remains the same. Query set 1 has a slight drop compared to 3D color histogram. This could be due to the fact that per-channel color histogram does not hold the color information, but the channel information. It is more likely that two different (non-identical) images have the same channel distribution than the color distribution. For example, consider a pair of 2 pixel images, one having a blue and a red pixel, whereas the other having two purple pixels. They may have the same per-channel color histogram whereas they cannot have the same 3D color histogram.

**I picked quantization interval 16 for the next sections. Table 2 does not show any difference, however table 1 slightly differs in query set 3 with 0.05%**

### 3 Grid Based Feature Extraction - Query set 1

Give your top-1 accuracy for all of the configurations below.

#### 3.1 $48 \times 48$ spatial grid

- 3d color histogram: 1.0
- per-channel histogram: 0.995

#### 3.2 $24 \times 24$ spatial grid

- 3d color histogram: 1.0
- per-channel histogram: 1.0

#### 3.3 $16 \times 16$ spatial grid

- 3d color histogram: 1.0
- per-channel histogram: 0.98

#### 3.4 $12 \times 12$ spatial grid

- 3d color histogram: 1.0
- per-channel histogram: 0.975

#### 3.5 Questions

- What do you think about the cause of the difference between the results?  
As I explained in section 2, per-channel histogram does not give the color information, but it gives the channel information. Therefore, 3D color histogram may give larger results in average.
- Explain the advantages/disadvantages of using grids in both types of histograms if there are any.  
We see there is a peak when using 24x24 spatial grid. Smaller grid sizes give worsened results. It may be advantageous to use 24x24 spatial grid for query set 1.

### 4 Grid Based Feature Extraction - Query set 2

Give your top-1 accuracy for all of the configurations below.

#### 4.1 $48 \times 48$ spatial grid

- 3d color histogram: 0.66
- per-channel histogram: 0.41

#### 4.2 $24 \times 24$ spatial grid

- 3d color histogram: 0.56
- per-channel histogram: 0.135

#### 4.3 $16 \times 16$ spatial grid

- 3d color histogram: 0.535
- per-channel histogram: 0.08

#### 4.4 $12 \times 12$ spatial grid

- 3d color histogram: 0.575
- per-channel histogram: 0.045

## 4.5 Questions

- What do you think about the cause of the difference between the results?  
Similar answer to previous section, 3D color histogram gives more distinguishing histograms, therefore, it is less likely to retrieve incorrect images than per-channel color histograms.
- Explain the advantages/disadvantages of using grids in both types of histograms if there are any.  
Because the images are rotated, corresponding grids may not have the same color or channel distribution. Therefore, it is disadvantageous for query set 2 to use grids.

## 5 Grid Based Feature Extraction - Query set 3

Give your top-1 accuracy for all of the configurations below.

### 5.1 $48 \times 48$ spatial grid

- 3d color histogram: 0.135
- per-channel histogram: 0.185

### 5.2 $24 \times 24$ spatial grid

- 3d color histogram: 0.145
- per-channel histogram: 0.18

### 5.3 $16 \times 16$ spatial grid

- 3d color histogram: 0.205
- per-channel histogram: 0.205

### 5.4 $12 \times 12$ spatial grid

- 3d color histogram: 0.225
- per-channel histogram: 0.205

## 5.5 Questions

- What do you think about the cause of the difference between the results?  
As explained in section 2, applying color filter modifies the color spectrum more than the channel spectrum. This may be the reason why per-channel histogram shows better results.
- Explain the advantages/disadvantages of using grids in both types of histograms if there are any.  
When a color filter is applied to an image, its probability distribution shifts its weight towards the intensity region closest to filter's color values. As grids get smaller, the effect of this shift (difference) is less, hence making smaller grids more similar to each other, for an image and a color filtered counterpart. That may be the reason why 12x12 grid dominates others and would be a better option compared to others.

## 6 Additional Comments and References

Caching is used in order to increase the performance so that images that had their histograms calculated will not ever need calculation again. Caching histograms gives considerable speedup; however, caching the images read by opencv is not tested, but also implemented.