CENG 483

Introduction to Computer Vision

Fall 2023-2024

Take Home Exam 1
Instance Recognition with Color Histograms
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1 3D Color Histogram (RGB)

Q. Interval	Query Set		
	Query 1	Query 2	Query 3
128	58.5%	100%	4.5%
64	90.5%	100%	14%
32	97%	100%	14%
16	98%	100%	14.5%

Table 1: Top-1 accuracy results using 3D color histogram (RGB).

A histogram provides information about the intensity or color distribution in an image or signal. When the quantization interval gets larger, information lose increase. One can easily observe the increase in the accuracy with the decreasing quantization interval. In addition, since histogram carries the index information (location-invariant), any operation done to an image, which does not change the number of occurrences of the each intensity value will not have an effect on the histogram. For example, Query 2 set achieves 100% accuracy with each quantization intervals, because the operation done to the query2 set is "rotation". However, even though the images in Query3 shows the same scenes, the histogram intersection becomes insufficient since the color intensity values are changed.

2 3D Color Histogram (HSV)

Q. Interval	Query Set		
	Query 1	Query 2	Query 3
128	59.5%	100%	11%
64	97%	100%	20.5%
32	100%	100%	22%
16	100%	100%	21%

Table 2: Top-1 accuracy results using 3D color histogram (HSV).

The spatial meaning of RGB color histograms is related to the distribution of intensity values in individual color channels R,G and B, while the spatial meaning of HSV color histograms is related to perceptual attributes such as hue, saturation and value. In the experiment with Query-1, we observe that there is a small improvement in the accuracy. Because the lack of data resulting from the center crop done in Query-1 has been compensated. When it comes to query-2, results are again promising due to the same reason as explained in the above section (2). For Query3, we observe a more significant increase in the accuracy because HSV space is more applicable to use to detect the type of the color instead of its intensity. For example, in the cases such as a dark red and a lighter one represent the same value, since they are both the same color.

3 Per-Channel Color Histogram (RGB)

Q. Interval	Query Set		
	Query 1	Query 2	Query 3
128	55.5%	99.5%	4%
64	91.5%	100%	14%
32	97%	100%	17%
16	97%	100%	19%
8	97.5%	100%	18.5%

Table 3: Top-1 accuracy results using per-channel color histogram (RGB).

As in the 3D Color Histogram, here Query2 set has the best accuracy values, because of the same reason, which is the fact that the number of occurences of the color intensity values does not change. As in the 3D color histogram RGB experiments again, the increase in the accuracy with decreasing intervals, and the significantly low value of Query3 accuracies persist, again due to the above explained reasons (color change, location change difference etc.)

When we compare the results between the 3D and per-channel versions of the same experiment configurations, we see that there is not a significant difference that is observed. Firstly, per-channel settings are observed to show a better accuracy in general .In addition, in the per-channel setting, the increase trend of the accuracy with the decreasing quantization interval persist, which cannot in the 3D setting. This may be related to the number of interval change effect on the 3D setting.

4 Per-Channel Color Histogram (HSV)

Q. Interval	Query Set		
	Query 1	Query 2	Query 3
128	63.5%	100%	18%
64	97%	100%	39%
32	100%	100%	37.5%
16	100%	100%	38%
8	100%	100%	39%

Table 4: Top-1 accuracy results using per-channel color histogram (HSV).

In the HSV setting, we can observe the increase in the all three query set experiments. This is stemming from the same reason as explained in the 3D HSV section, which is about storing the color type instead of the color intensity. Therefore, the most significant increase is observed in the Query set 3 because it is the color changed version of the support set and HSV space compensates this difference.

Best Configuration

- Color space: HSV

- Quantization interval for 3D color histogram: 16

- Quantization interval for per-channel color histogram: 8

5 Grid Based Feature Extraction - Query set 1

Histogram Type	Spatial Grid			
	2×2	4×4	6×6	8×8
3D	100%	100%	100%	100%
Per-Channel	100%	100%	100%	100%

Table 5: Top-1 accuracy results on query set 1.

5.1 Questions

- In this set, we do not observe any difference between the different configurations.

- In this query set, we can easily see that we have a much better performance of the histogram intersection technique, as dividing into grids provides a better understanding of the spatial meaning of the specified regions of the input image.

6 Grid Based Feature Extraction - Query set 2

Histogram Type	Spatial Grid			
	2×2	4×4	6×6	8×8
3D	58.5%	47.5%	44.5%	43.5%
Per-Channel	64.5%	52.5%	46%	44%

Table 6: Top-1 accuracy results on query set 2.

6.1 Questions

- In this set, we can easily observe the decrease trend when we increase the number of spatial grids. The reason behind this trend is basically the fact that the images in the Query-2 set is rotated. When we observe the whole image, we can see the similarities. However, when we zoom in to some small regions, it gets harder to observe this similarity since the indexes are changed.

- In the rotation case (described above) we see that using the per-channel setting provides a better accuracy, meaning that it is more advantageous since the number of occurrences of color intensities in each channel did not change.

7 Grid Based Feature Extraction - Query set 3

Histogram Type	Spatial Grid			
	2×2	4×4	6×6	8×8
3D	34%	52%	62%	66.5%
Per-Channel	54.5%	68.5%	77%	80.5%

Table 7: Top-1 accuracy results on query set 3.

7.1 Questions

- In the Query-3 set, we know that the color intensity values are transformed/changed. When we compare the experiments with the different grid number configurations, we can observe that the accuracy increases with the increasing number of grids. The reason of this is when the grid size decrease, the distributions have a better understanding of the meaning of the scene, when we use the HSV color space.

- The per-channel setting seems to be more advantageous compared to the 3D color histogram. The reason here may be the fact that using the mean of the per-channel similarities hold more valuable information compared to the 3D setting, since the difference between the Query3-set and support set is their color values.

8 Additional Comments and References

This THE was very useful in terms of gaining and insight related to these topics. Thanks in advance for this valuable work.