Assignment 1

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1 PROOF

1.1

Show that a 2D Gaussian filter is separable into two 1D Gaussian filters.

$$p(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{x^2}{2}} \tag{1}$$

Proof.

$$p(x)p(y) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{x^2}{2}} * \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{y^2}{2}} = \frac{1}{2\pi\sigma^2} e^{-\frac{x^2y^2}{2}} \tag{2}$$

□

1.2

Derive the 1st derivative of 2D Gaussian filter.

$$G(x, y) = \frac{1}{2\pi\sigma^2} e^{-\frac{x^2y^2}{2}} \tag{3}$$

1-derivative :

$$\frac{\delta G}{\delta x} = (-\frac{1}{2\pi\sigma^4}) x e^{-\frac{x^2y^2}{2\sigma^2}}, \frac{\delta G}{\delta y} = (-\frac{1}{2\pi\sigma^4}) y e^{-\frac{x^2y^2}{2\sigma^2}} \tag{4}$$

1.3

Derive the 2nd derivative of 2D Gaussian filter.

$$\frac{\delta^2 G}{\delta x^2} = (-\frac{1}{2\pi\sigma^4})(1 - \frac{x^2}{\sigma^2}) e^{-\frac{x^2y^2}{2\sigma^2}}, \frac{\delta^2 G}{\delta y^2} = (-\frac{1}{2\pi\sigma^4})(1 - \frac{y^2}{\sigma^2}) e^{-\frac{x^2y^2}{2\sigma^2}} \tag{5}$$

1.4

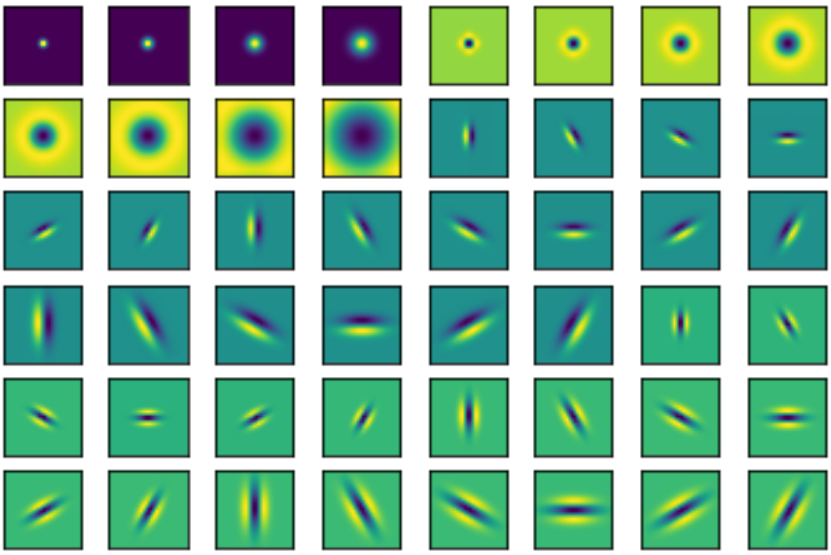
Derive the Laplacian of Gaussian (LoG) filter

$$\frac{\delta^2 G}{\delta x^2} + \frac{\delta^2 G}{\delta y^2} = (-\frac{1}{2\pi\sigma^4})(1 - \frac{x^2}{\sigma^2}) e^{-\frac{x^2y^2}{2\sigma^2}} + (-\frac{1}{2\pi\sigma^4})(1 - \frac{y^2}{\sigma^2}) e^{-\frac{x^2y^2}{2\sigma^2}} = \frac{x^2 + y^2 - 2\sigma^2}{\sigma^4} e^{-\frac{x^2+y^2}{2\sigma^2}} \tag{6}$$

2 CONVOLUTION

2.1

Display the 48 image filters in the report.



2.2

Display the 48 image responses of the images “leapord.jpg” and “panda.jpg” after performing convolution with the filter bank.

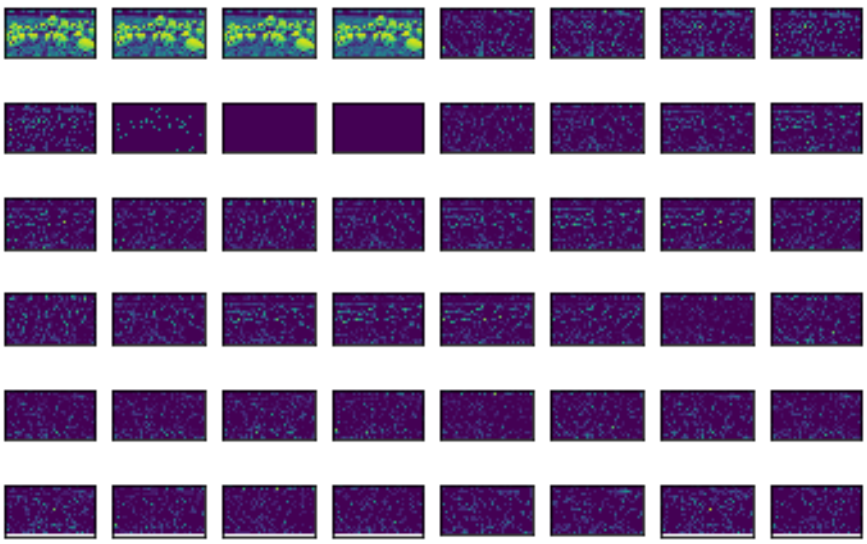


Figure 1: pandas

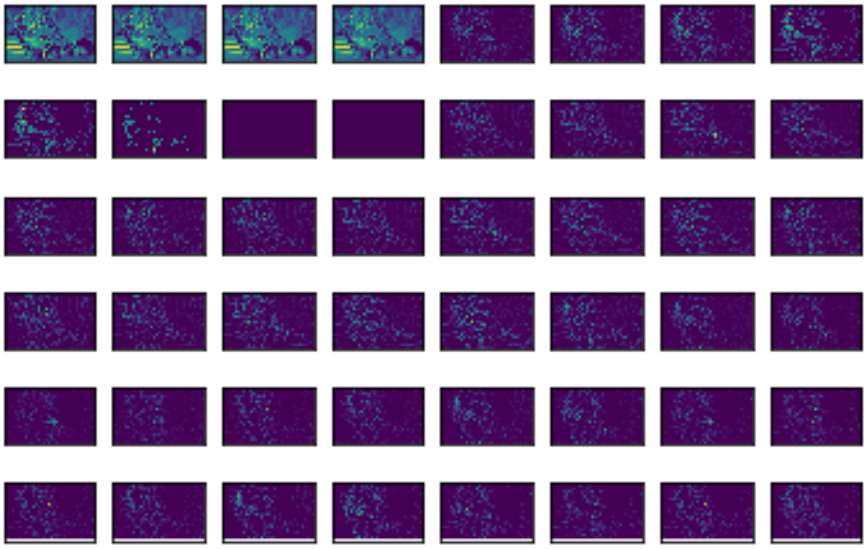


Figure 2: leopard

2.3

Compute the mean and variance of each image response to form a vector of length 96 elements. Write down the filter that gives the largest value of mean and the filter that gives the largest value of variance for "leapord.jpg" and "panda.jpg" in the report.
For panda, 2nd and 1st filters give the largest value of mean and the largest value of variance respectively.
For leapord, 1st filter gives the largest value of mean and the largest value of variance respectively.

3 IMAGE RANKING

You are given a collection of 2,000 images and 5 query images (in the canvas). You need to extract visual features from these images by performing convolution with the 48 filters Your task is: For each query, retrieve the five most similar images from the collection of 2,000 images. Show the five most similar images of each query in the report.

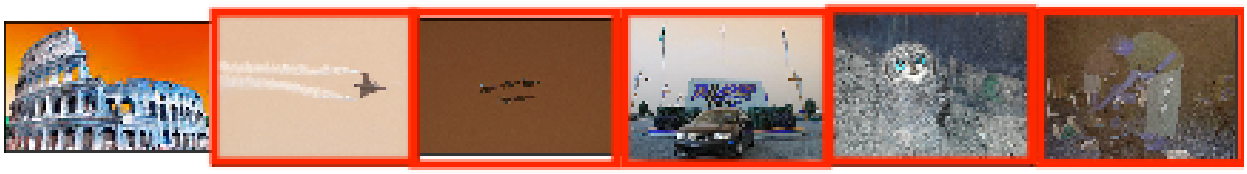


Figure 3: Q1

Figure 4: Q2

Figure 5: Q3

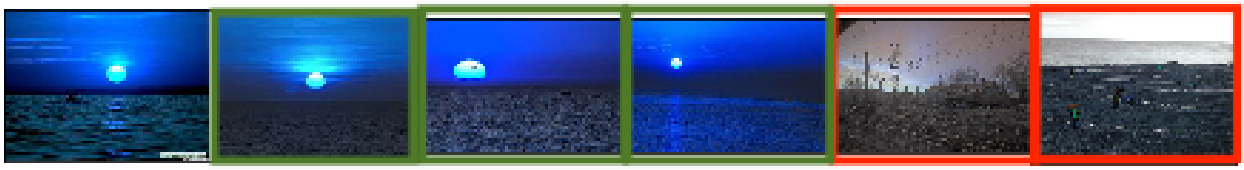


Figure 6: Q4

Figure 7: Q5

4 METHOD COMPARISON

4.1

Implement any two feature extraction methods that you know (e.g., color histogram, LBP, SIFT, deep learning) to extract features for 2,000 images in Part-3. Show the five most similar images of each query for each method.

I use and color histogram and deep learn here. As we can see, the results of deep learning are the best.

Color histogram:

Figure 8: Q1

Figure 9: Q2

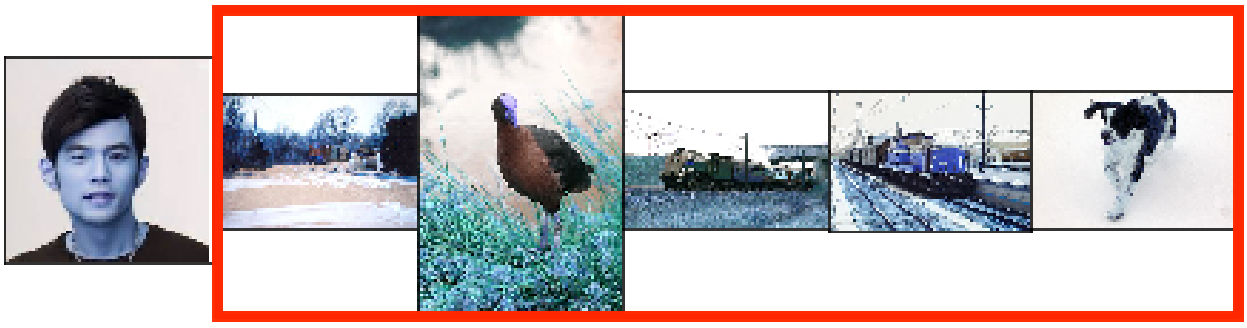


Figure 10: Q3

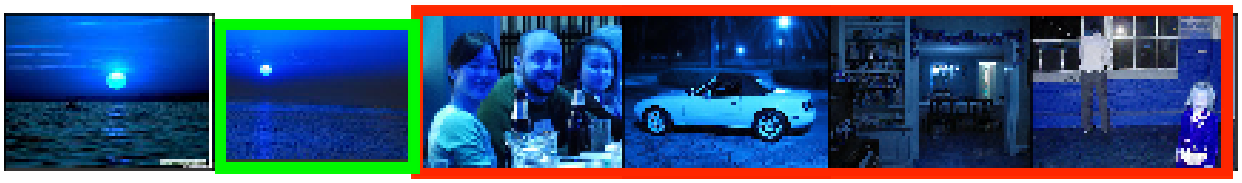


Figure 11: Q4

Figure 12: Q5

Deep Learning:

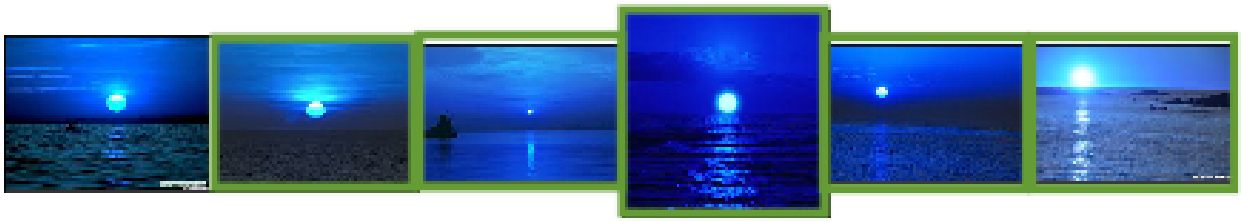


Figure 13: Q1

Figure 14: Q2

Figure 15: Q3

Figure 16: Q4

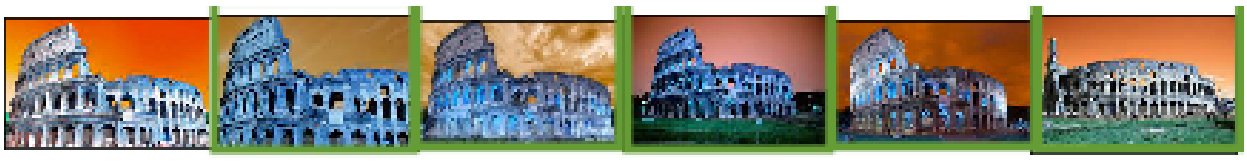


Figure 17: Q5

4.2

Compare the retrieval result with the performance obtained in Part-3.

method	false	true	percentage
fiter	22	3	12%
color histogram	24	1	4%
deep learning	0	25	100%

4.3

Propose a method to fuse (or combine) the results in Part-3 and Part-4. Show the five most similar images of each query.

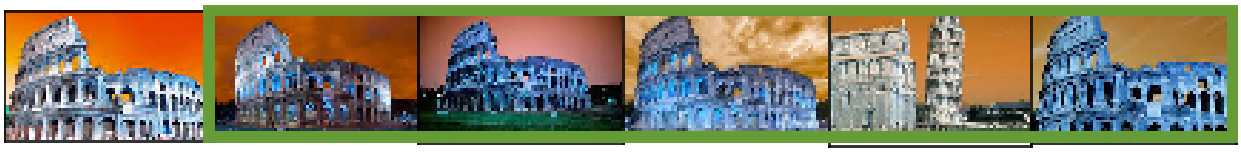


Figure 18: Q1

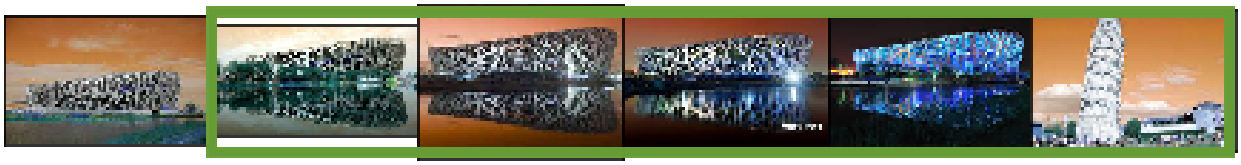


Figure 19: Q2

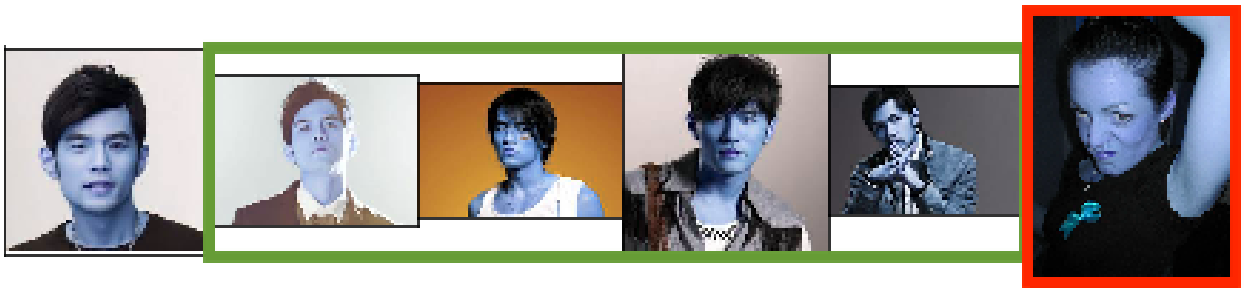


Figure 20: Q3

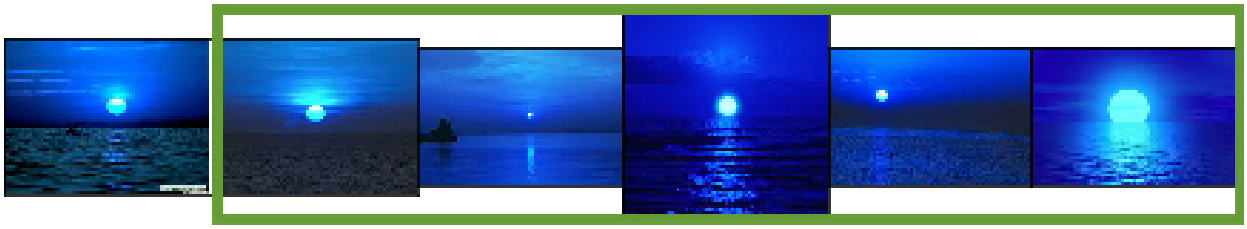


Figure 21: Q4

Figure 22: Q5

5 COMPETITION

Here is deep learning results:
Q1:1393 1175 0638 0791 0876 1745 ...
Q2:0388 1178 0531 0709 0657 1470 ...
Q3:0267 1873 0003 1063 0509 0170 ...
Q4:0342 1631 0865 0721 0037 1810 ...
Q5:1825 0779 1976 0029 0915 0702 ...