CS-4243, S 2023-1, Coursework 1

Coursework Description

- This coursework consists of two parts, comprising five questions, and contributes to a total of 9 CA marks out of the final 100-mark evaluation.
  - Part 1: Four multiple-choice questions (MCQs), each worth 2 marks (8 marks in total). Each MCQ has a **single** correct answer. There is no penalty for incorrect answers. Please select the **best and most accurate** option.
  - Part 2: Long answer question, worth 1 CA mark.
- The coursework will be submitted through a Canvas Quiz. The CW1 quiz will be available soon. Different parts and questions in the quiz have been appropriately categorized. For instance, Part 1 consists of MCQs, and Part 2 comprises essay questions where you can include images or attach files to your responses.
- The CW1 quiz will be accessible in the Canvas "Quizzes" folder, allowing you to submit your coursework.
- The coursework is due on **24 Sept 2023, 11:59 pm**.
- Good luck, my friends

Part 1. MCQs (2 marks each)

1. Consider the grayscale image named 20220511_105950gl.jpg and the four interpolation algorithms denoted by x, where x ranges from 0 to 3 (or x=[0,1,2,3]):

- x=0 ➔ INTER_NEAREST algorithm
- x=1 ➔ INTER_LINEAR algorithm
- x=2 ➔ INTER_CUBIC algorithm
- x=3 ➔ INTER_AREA algorithm

Let's refer to our image as a. Using one of the above interpolation algorithms, denoted by x, we will zoom out a with a scale of 0.25, effectively making it four times smaller. This zoomed-out version will be called zoa_x. Subsequently, we will zoom back in on zoa_x with a scale of 4, using the same interpolation algorithm denoted by x. The resulting image will be referred to as zia_x. Calculate the absolute difference between the original image a and zia_x, which we'll label as $adiffa_x$. Repeat this process for all four interpolation algorithms and determine the best answer. Utilize the OpenCV resize function for these operations.

Note that the absolute difference can be computed as

$$\begin{cases} adiff(p,q) = \sum_{i=1}^{M}\sum_{j=1}^{N}|p(i,j) - q(i,j)| \\ \qquad adiffa_x = adiff(a, zia_x) \end{cases}$$

where images p and q share the same size of MxN. We will interpret $adiffa_x$ as an indicator of the quality of the interpolation algorithm. A smaller $adiffa_x$ value indicates a higher quality/ performance for algorithm x. Select the option that best represents the quality of the four interpolation algorithms.

a. $adiffa_1 < adiffa_2 < adiffa_0 < adiffa_3$
b. $adiffa_0 < adiffa_1 < adiffa_2 < adiffa_3$
c. $adiffa_2 < adiffa_1 < adiffa_3 < adiffa_0$
d. $adiffa_2 < adiffa_1 < adiffa_0 < adiffa_3$

2. Consider the input image 20230513_190534gl.jpg. We will refer to it as b. Apply a 5x5 Gaussian filter, denoted as h_{GLP}, to image b. The results of this operation will be labeled as b_{GLP}. Calculate the power and entropy for both images b and b_{GLP}.

Next, take the input image 20230324_105524gl.jpg and name it c. Repeat the same process for image c, obtaining the power and entropy of both images c and c_{GLP}.

Following these calculations, select the best answer. Our aim is to observe the effects of low-pass filtering on the power and entropy of different images, considering the visual attributes of each image. Focus on the ratio of power and entropy before and after filtering. You can utilize the functions available in the **utils_2023** notebook for this analysis.

$$h_{GLP} = \frac{1}{273} \begin{bmatrix} 1 & 4 & 7 & 4 & 1 \\ 4 & 16 & 26 & 16 & 4 \\ 7 & 26 & 41 & 26 & 7 \\ 4 & 16 & 26 & 16 & 4 \\ 1 & 4 & 7 & 4 & 1 \end{bmatrix}$$

a. For b, the filter relatively cuts more percentage of power compared to c, because b has got more high-frequency components/ details compared to c. The change in entropy, however, is not significantly different for b and c.
b. For b, the filter relatively cuts more percentage of power compared to c, because b is a long-shot image compared to c. The same can be said about the entropy.
c. For c, the filter relatively cuts more percentage of power compared to b, because c has got more high-frequency components/ details compared to b. The change in entropy, however, is not significantly different for b and c.
d. For c, the filter relatively cuts more percentage of power compared to b, because c has lost more details and information during colour to gray level transformation, compared to b. The same can be said about the entropy.

3. The input image for testing Fourier domain bandpass filtering is IMG_0699_1024.png, referred to as c. Your task is to choose the best option/answer concerning the power of the filtered images. In computer vision and signal processing, the power of the filtered image is also known as the *filter response*.
   - Compute the Fourier transform of your input image.
   - Develop a bank of Butterworth bandpass filters as follows:
     - F0 = ButterworthBandPass(1024,1024, 0.05, 0.1, 1)
     - F1 = ButterworthBandPass(1024,1024, 0.1, 0.2, 1)
     - F2 = ButterworthBandPass(1024,1024, 0.2, 0.4, 1)
     - F3 = ButterworthBandPass(1024,1024, 0.4, 0.8, 1)
   - For each filter F0 to F3 in your filter bank:
     - Apply the filter on your image c, resulting in the images labeled as FcF_i, where i ranges from 0 to 3.
     - Apply the inverse transform to obtain the resulting image.
     - Calculate the power of the resulting image, which will be denoted as PcF_i, where i ranges from 0 to 3.
   - Based on your calculations, select the best and most accurate answer from the options below.

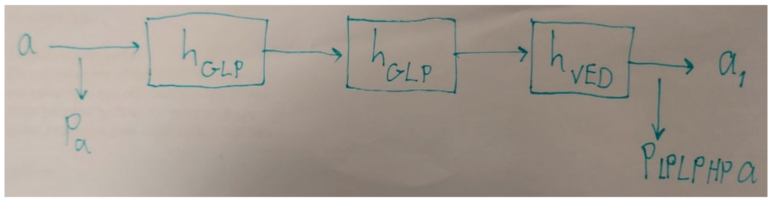
   a. No conclusion can be made by comparison of PcF_0 to PcF_3, while the last filter parameter doesn't play any significant role in the filtering, setting of the lower and higher cut-off frequencies is based on $\log_2$ scale to keep the frequency/information relevant.
   b. $PcF_0 > PcF_1 > PcF_2 > PcF_3$, the last filter parameter is significant, setting of the lower and higher cut-off frequencies is based on $\log_2$ scale to keep the frequency to information rate relevant.
   c. $PcF_0 = PcF_1 > PcF_2 = PcF_3$, the last filter parameter is significant, setting of the lower and higher cut-off frequencies is based on the $\log_2$ scale to keep the frequency/information relevancy.
   d. $PcF_0 > PcF_1 > PcF_2 > PcF_3$, the last filter parameter is not significant, setting of the lower and higher cut-off frequencies are set to cover all the spatial frequency components.

4. Below is a vertical edge detector filter referred to as h_{VED}. The test image for this purpose is IMG_20200111_141756.jpg, denoted as a in this context.

$$h_{VED} = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix}$$

   1. Calculate the power of the original image a, which will be denoted as P_a.
   2. Apply the vertical edge detector filter h_{VED} to image a and compute the power of the resulting filtered image, denoted as Php_a.
   3. Filter image a with the Gaussian filter h_{GLP} (from Question 2). Next, apply the vertical edge detector filter h_{VED} to the filtered image and compute the power of the resulting image, $Plphp_a$.

4. Filter image a with the Gaussian filter h_{GLP} (from Question 2) twice. Next, apply the vertical edge detector filter h_{VED} to the twice-filtered image and compute the power of the resulting image, $Plplphp_a$.
5. Open a new image named high_spat_freq.bmp and label it as b.
6. Repeat the entire process outlined above for image b. Calculating P_b, Php_b, $Plphp_b$, and $Plplphp_b$.



Select the best/most correct answer below.

a. b loses more power after high pass filtering compared to a. The $\frac{Plplphp_a}{Php_a}$ ratio is clearly larger than the $\frac{Plplphp_b}{Php_b}$ ratio. We can conclude that b is noisier than a.

b. a loses more power after high pass filtering compared to b. The $\frac{Plplphp_a}{P_a}$ ratio is significantly smaller than $\frac{Plplphp_b}{P_b}$ ratio. Also, the $\frac{plplphp_a}{Php_a}$ ratio is clearly smaller than the $\frac{Plplphp_b}{Php_b}$ ratio. We can conclude that presence of high frequency components in a is much more than b.

c. a loses more power after high pass filtering compared to b. The $\frac{Plplphp_a}{P_a}$ ratio is significantly smaller than $\frac{Plplphp_b}{P_b}$ ratio. However, the $\frac{Plplphp_a}{Php_a}$ ratio is clearly larger than the $\frac{Plplphp_b}{Php_b}$ ratio. We can conclude that presence of high frequency components in b is much more than a.

d. $P_b > P_a > Php_b > Php_a > Plplphp_b > Plplphp_a$, because a shows a lower image quality compared to b.

Part 2. Long answer Question (1 mark)

5. Why are the tail lights of vehicles red, not yellow or blue? Mention your reasons and explanation in up to 100 words, please.

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