DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING
INDIAN INSTITUTE OF TECHNOLOGY (INDIAN SCHOOL OF MINES), DHANBAD

QUIZ-I

Examination: **VIII Dual Degree (CSE)** Time: **02 Hours**

Subject: **Image and Video Processing Lab (CSC18205)** Max. Marks: **20**

Instructions:

1. **Program file** should be named as **Admission_no.**, e.g., 17JE0514. Before leaving the online session, attach your **file** and send it to ivplabexam@gmail.com for the evaluation.
2. Must write your **Admission number**, **Name**, and **IVPLab_Quiz1** in the **subject line of the e-mail.** (e.g., IVPLab_Quiz1:17JE0514_Shashank Tripathi**)**.
3. **Use of Internet is strictly prohibited.** You **must not** copy code from the internet. **Plagiarism** of the submitted code will be checked and if your code found to be copied from any source, your exam will be **cancelled**. If your code is found **copied from any other student**, then both students will get **zero marks**.
4. **Must** choose the correct option based on your coding in the **Google form**. However, evaluation will solely be based on the submitted code.

Write a program to obtain a binary image preceded by Histogram equalization (HE) process:

(A) HE is one of the common methods used for improving contrast in images. However, this technique introduces unnecessary visual deterioration such as the saturation effect. Hence, abide by the following constraint to generate a histogram equalized image by preserving the mean brightness of the input image inside the output image obtained after the histogram equalization:

(i) *Smoothen the image with Gaussian filter*

As the histogram of the digital image is normally fluctuated and also the probability for some brightness levels is missing so at first, fill up the disappeared brightness levels using one dimensional Gaussian filter. Apply Gaussian filter of size 1×9 and σ equal to 1.0762.

(ii) *Detect the local maximums from the smoothed histogram*

Divide histogram of the smoothed image into sub-histograms based on local maximums which represent the separating intensities. Take number of local maximums (N) as input from the user.

(iii) *Map each partition into a new dynamic range*

Let $m_0, m_1, \ldots, m_{N-1}$ are N gray-values corresponding to the local maximums detected in the previous step. If the original histogram before the smoothing is in the range of $[I_{min}, I_{max}]$, then, the first sub-histogram is in the range of $[I_{min}, m_0]$, the second sub-histogram in the range of $[m_0 + 1, m_1]$, the third one is in $[m_1 + 1, m_2]$, so on and the last sub-histogram is in the range of $[m_{N-1}+1, I_{max}]$. Perform spanning over each sub-histogram using the spanning function as following:

$$span_i = high_i - low_i$$

$$factor_i = span_i \times \log_{10} M$$

$$range_i = (L-1) \times \left(\frac{factor_i}{\sum_{k=1}^{N+1} factor_k}\right)$$

where $high_i$ is highest intensity value contained in the sub-histogram i, low_i is lowest intensity value in that section, and M is the total pixels contained in that section. Dynamic range used by the sub-histogram i in input image is given by $span_i$ while the dynamic range used in output image is given by $range_i$. L represents the number of gray levels in input image. Let the range of output sub-histogram i is $[start_i, end_i]$. If first sub-histogram of the output image is in the range of $[0, range_1]$, then calculate the $start_i$ and end_i (for $i > 1$) as following:

$$start_i = \sum_{k=1}^{i-1} range_k + 1$$

$$end_i = \sum_{k=1}^{i} range_k$$

(iv) ***Equalize each partition independently***

The next step, equalize each partition independently. For sub-histogram i with the range of $[start_i, end_i]$, perform the equalization of each section as following:

$$y(x) = start_i + (end_i - start_i) \sum_{k=start_i}^{x} \frac{n_k}{M}$$

where n_k is the number of pixels with intensity k, M is the total pixels contained in that section, and $x \in [start_i, end_i]$.

(v) ***Normalize the image brightness***

In this step, calculate the mean brightness of the input image, M_i, and the mean brightness of the output image obtained after the equalization process, M_0. In order to shift back the mean brightness of output image to the mean brightness of the input, perform the brightness normalization as following

$$g(x,y) = (M_i/M_0)f(x,y)$$

where $g(x,y)$ is the final output image, and $f(x,y)$ is the output image obtained just after the equalization process.

[**Note:** If required, use padding to deal with border pixels.]

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(B) After histogram equalization process, obtain corresponding binary image by applying threshold $T(x,y)$ over the output image such that

$$b(x,y) = \begin{cases} 0, & if\ g(x,y) \leq T(x,y) \\ 255, & otherwise \end{cases}$$

Threshold $T(x,y)$ is calculated for each pixel based on local statistics of the neighborhood pixels within a block of size $w \times w$ where $g(x,y)$ is the gray-scale image such that $g(x,y) \in [0,255]$ be the intensity of a pixel at location (x,y) and $b(x,y)$ is the output image obtained after applying thresholding. Write a program where threshold $T(x,y)$ is computed using the *mean* $m(x,y)$ and *standard deviation* $\delta(x,y)$ of the pixel intensities in a $w \times w$ window centered around the pixel at (x,y) and can be expressed as:

$$T(x,y) = m(x,y)[1 + K(\frac{\delta(x,y)}{R} - 1)]$$

where R is the standard deviation of image and K is a parameter which takes positive values in the range $[0.2, 0.5]$. Take K and w as input from the user.
[**Note:** If required, use padding to deal with border pixels.]

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Sample input image