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Programming Assignment - 1

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Question1: Scaling and Quantization

Preprocessing step: Extracted the grey image

(a)

Grey levels(2^k)	**Original Image**	**2^2(4)**	**2^4(16)**	**2^8(256)**
Images				
Observations	It's Original Image	We can observe the very less smoothness/continuity in image as the image is stored in less grey levels as compared to original image and very sharp transition from high frequency to low frequency – vice versa. As observed on the floor, skin of woman.	We can observe the good smoothness/continuity achieved in image as the grey levels increased compared to previous 4 grey levels image and comparitively smooth transition from high frequency to low frequency – vice versa. The image is more pixeleted here as compared to original image. As pixels can be observed on forehead of woman and other skin areas. As observed on the floor, skin tone of woman.	As it has same number of grey levels as original image. So we don't observe any difference in comparison to original image.

(b)

K-number of clusters	Original Image	2	8	16
Images				
K-number of clusters	**32**	**40**		
Images				

Observations:

We can observe that as K increases the number of grey levels increases as number of clusters increase. Here the K-centroids are chosen on the basis of image obtained through K-means clustering algorithm. Thus as the number of grey levels increases the image becomes more smoother and more continuity is observed.

Question2: Image Interpolation

(A) Linear Interpolation

Input image | **Output Image (Upscaled Image)**

Shape: (1). (510x510) (2). (1020x1020)

Observations:

Here linear interpolation is used to resize the image by 2 times. It is done by doing padding upto the scaed value and then using the interpolation kernel function to get pixel values for the coordinates that are to be interpolated and here first row-wise interpolation is done followed by column wise interpolation. From the above two figures we can observe that the smoothness is less on resizing the image, we may see better smoothing on doing bicubic interpolation.

Output Image (Upscaled Image) | **Output Image (Downscaled Image)**

Shape: (1). (1020x1020) (2). (510x510)

Observations:

Here also linear interpolation kernel function is used to get the downsampled image by 1/2 times the upsampled image(i.e. equal to the input image size). In comparision with downsampling we can observe that the image quality is not as good as original image this is because interpolation effects.

(B) Bi-cubic Interpolation

Input image **Output Image (Upscaled Image)**

Shape: (1). (510x510) (2). (1020x1020)

Observations:

Here bicubic interpolation is used to resize the image by 2 times. Similarly it is also done by using bicubic interpolation kernel function to get the pixel values for the new cordinates to be interpolated. Here we can observe that we have got the upscaled image but has more smoother interpolation as compared to linear interpolation as it is done by using cubic interpolation function.

Output Image (Upscaled Image) **Output Image (Downscaled Image)**

Shape: (1). (1020x1020) (2). (510x510)

Observations:

Here also linear interpolation kernel function is used to get the downsampled image by 1/2 times the upsampled image(i.e. equal to the input image size). Similaryly here also we get much smoother interpolation as compared to linear interpolation downasmpled image. Here we can see much smoother transition from low freuwncy compontents to high freuwuancy components and vice-versa as we can see on floor and woman and chair stripes.

Question3: Affine Transformation

In transformation of image we multiply each coordinate of image by the particular transformation matrix to get the new coordinate values.

(a) Translation by 2 pixels in both x and y direction

Observations: As we can see black portion in right side and upper part of image. This is due to translating in both x and y directions by 2pixels each.

Translation matrix: [[1,0,2],
[0,1,2],
[0,0,1]]

(b) Scaling by factor of 2 in x-direction

Observations: As we can see the image is scaled by scaling factor of 2 in x-direction i.e in width is increaded twice the width of the original image. Here also we can visualize there is need to intepolate the values also after scaling to fill the inner missing values.

Scaling matrix: [[2,0,0],
[0,1,0],
[0,0,1]]

(c) Rotation by 30 degrees in anti-clockwise direction

Observations: As we can see the image is rotated by 30 degrees in anticlockwise direction. We can also visulaize the whole image is not represnted in the same size as original because the new coordinate values we get after multiplying with roation matrix are out of the size of the original image so we need to pad originally so that we can get the coordinates which are not covered in the shown image. Here also we can visualize there is need to intepolate the values also after scaling to fill the inner missing values.

Rotation matrix: [[cos(-30 radians),-sin(-30 radian),0],
[sin(-30 radian), cos(-30 radians),0],
[0, 0, 1]]

(d) Rotation followed by Scaling followed by Translation

Observations: As we can see the image is rotated by 30 degrees in anticlockwise direction then it is scale by factor of 2 in x-direction then it is trnaslated by 2-pixels in both x and y direction. in anticlockwise direction. Here also we can visualize there is need to intepolate the values also after scaling to fill the inner missing values.

Order of performing Transformations: (Translation x (Scaling x Rotation))

Question4: Gaussian and Laplacian Pyramid

- Here first we performed Gaussian upto G3 levels by performing Guassian blur and then down-sampling the image and continues in the similar manner.

- Then we performed Laplacian upto G0 levels by performing expanding the image and then subtracting from the Gaussian pyramid levels respectively.

Gaussian Pyramid

G0

G1

G2

G3

Laplacian Pyramid

L0

L1

L2

L3

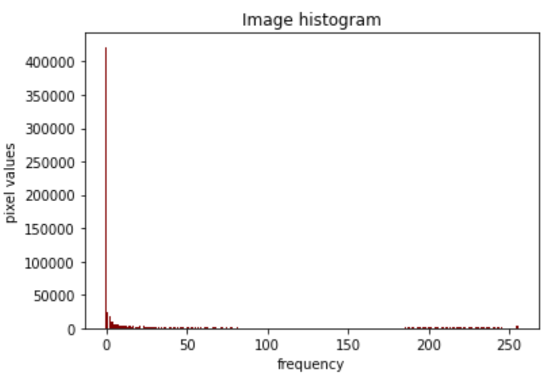
Observations:

- **Gaussian Pyramid:** Used the Gaussian blur filter of (5x5) filter of standard deviation of 0.5. Gaussian flitering is a low pass filter it helps in getting the low frequncy components of the image and then downsampled by 2 the interpolation that is contructed in the above Question2. By continuing in this fashion we will get the more low pass image. Thus by doing this it forms a pyramid like structure by everytime downsampling by factor of 2.

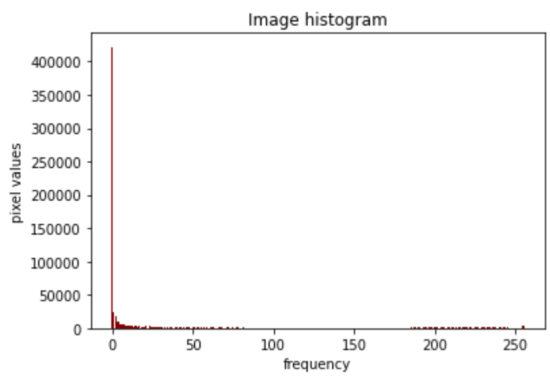
- **Laplacian Pyramid:** Here the upper level gaussian curves is exapnded and subtracted from the lower level Gaussain curves to get the laplacian image. The Laplacian is used to get the high frequency information. So it helps in getting the edges in the image. Here used the interpolation function defined in Question2 above to get twice the image for expanding the previous gaussian level image.

Question5: Histogram

Original | **Contrast stretched**



Standard deviation = 69.32

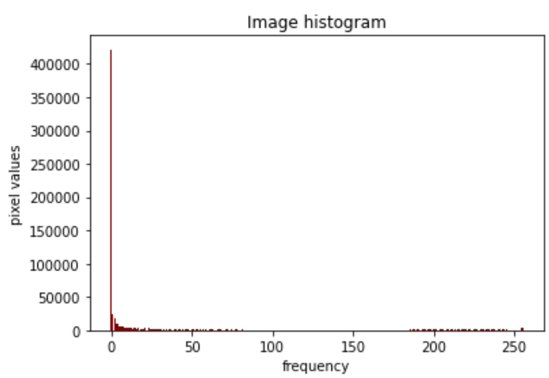


Standard deviation = 69.32

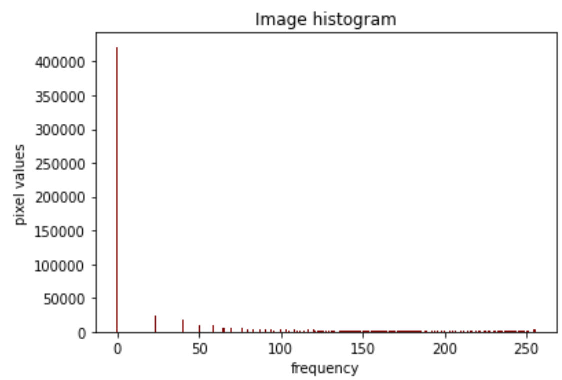
Observations:

From above images we can observe that there is no difference between original image histogram and contrast stretched histogram as the histogram of original image is already in range of 0-255 so it can’t be further stretched. Thus there is no difference in the standard deviation of both the histograms.

Original | **Histogram equalized**



Standard deviation = 69.32



Standard deviation = 76.98

Observations:

From above images we can observe that there is histogram equalization done which helps in increasing the standard deviation thus in turn increases the standard deviation from 69.32 to 76.98. Also we can see that the contrast of the image is increased as the standard deviation is increased. Did histogram equalization by calculating cdf and then calculating the further pixel values and thus number of pixels to equalize the histogram.

<u>Question6</u>: Image Watermarking Technique

<u>Steps Performed</u>:

1. **Performed Discrete Wavelet Transform (DWT) with 2 levels for content image/cover image.**
2. **Performed Discrete Wavelet Transform (DWT) with 1 level for watermark image.**
3. **Then hided/embedded the LL,LH,HL,HH wavelet coefficients of watermark image to the various wavelet coefficients of cover image in 2nd and 1st levels.**
4. **Then did Inverse Discrete Wavelet Transform (IDWT) on wavelet coefficients cover image now having hidden water mark image to get the Watermark-hidden content image.**
5. **Now performed steps to recover the watermark from this Watermark-hidden content image by performing the DWT of this image and then extracted the watermark from the wavelet levels as we know the key/coordinates where the watermark is hidden.**
6. **We can observe that there is some reconstruction error on comparing the extracted watermark with original watermark.**

Watermark Extraction using DWT (Discrete Wavelet Transform) Technique