Page No.
Date

Assignment-1

EE 610 - Image Processing

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Ques 1

Image size = 1024×1024

dpi of printer = $\frac{1024}{2}$ = 512 dpi

So Required Printer's resolution = 512 dpi

Ques 2

(a) Summation operation is linear.

Since by additivity property, for any two input images A and B

$$f(A+B) = f(A) + f(B)$$

By Homogenity
for a scalar 'c'

$$f(c * A) = c * f(A)$$

(b) Multiplication operation — Non-Linear.

Additivity : for any two input images A and B. Multiplying the pixel values individually is not same as multiplying the pixel values of two images. So it does not satisfy additivity property and is thus non-linear.

Q. 4

Ans 4

A single intensity transformation function can be given by

$$f(x) = \frac{(L-1)}{(I_{max} - I_{min})} \times (x - I_{min})$$

x = input intensity level of image.

Q3

(a) Scaling and Translation

$$F(x,y) = T(t_x, t_y) * S(S_x, S_y) * (x,y)$$

$$= \begin{bmatrix} S_x & 0 & t_x \\ 0 & S_y & t_y \\ 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} x \\ y \\ 1 \end{bmatrix}$$

Scaling and Translation function

(b) Yes order of multiplication does matter.

e.g. Let us have a point (2, 3)

first scaling, factor $S_x = 2$,

$$= \begin{bmatrix} 2 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} 2 \\ 3 \\ 1 \end{bmatrix} = \begin{bmatrix} 4 \\ 3 \\ 1 \end{bmatrix}$$

Page No.
Date

Now translation $t_x = 3$, $t_y = 4$

$$\begin{bmatrix} 1 & 0 & 3 \\ 0 & 1 & 4 \\ 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} 4 \\ 3 \\ 1 \end{bmatrix} = \begin{bmatrix} 7 \\ 7 \\ 1 \end{bmatrix}$$

Now we get (7, 7)

Now let's do translation first on (2, 3)

$$\begin{bmatrix} 1 & 0 & 3 \\ 0 & 1 & 4 \\ 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} 2 \\ 3 \\ 1 \end{bmatrix} = \begin{bmatrix} 5 \\ 7 \\ 1 \end{bmatrix}$$

Now scaling $S_x = 2$

$$\begin{bmatrix} 2 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} 5 \\ 7 \\ 1 \end{bmatrix} = \begin{bmatrix} 10 \\ 7 \\ 1 \end{bmatrix}$$

So we get (10, 7)

Thus order of geometric transformation matters.

Page No.
Date

Q5

(a) To extract the bit planes, convert pixel values to binary and then isolate individual bits to form seperate bit-plane images.

For bit plane 0 [LSB]

$$T_0(r) = r \,\&\, 1$$

For bit plane 1

$$T_1(r) = (r \gg 1) \,\&\, 1$$

For bit plane 2

$$T_2(r) = (r \gg 2) \,\&\, 1$$

For bit plane 3 [MSB]

$$T_3(r) = (r \gg 3) \,\&\, 1$$

$r \rightarrow$ pixel value of input
$\& \rightarrow$ bitwise AND
$\gg \rightarrow$ bitwise right shift.

(b) Given 4 bit image

$$\begin{bmatrix} 0 & 1 & 8 & 6 \\ 2 & 2 & 1 & 1 \\ 1 & 15 & 14 & 12 \\ 3 & 6 & 9 & 10 \end{bmatrix}$$

- Bit plane 0 (LSB)

$$\begin{bmatrix} 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 1 \\ 1 & 1 & 0 & 0 \\ 1 & 0 & 1 & 0 \end{bmatrix}$$

Page No.
Date

=> Bit plane 1

$$\begin{bmatrix} 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 1 & 1 & 1 \\ 1 & 1 & 0 & 1 \end{bmatrix}$$

=> Bit plane 2

$$\begin{bmatrix} 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 \end{bmatrix}$$

=> Bit plane 3 (MSB)

$$\begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

Page No.
Date

Ques 6

(a) Setting lower-order bit plane to zero reduces intensity resolution and lead to coarser representation of the data.

The effect on histogram is that the unique intensity values will become less. The histogram's peaks and valleys will become less pronounced.

(b) Setting higher order bit planes to zero would have reduced the image's overall brightness level.

The effect on histogram would be reduction of dynamic range of intensities. The histogram's distribution would become narrower.

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