PRINCE OF SONGKHLA UNIVERSITY
FACULTY OF ENGINEERING
Department of Computer Engineering

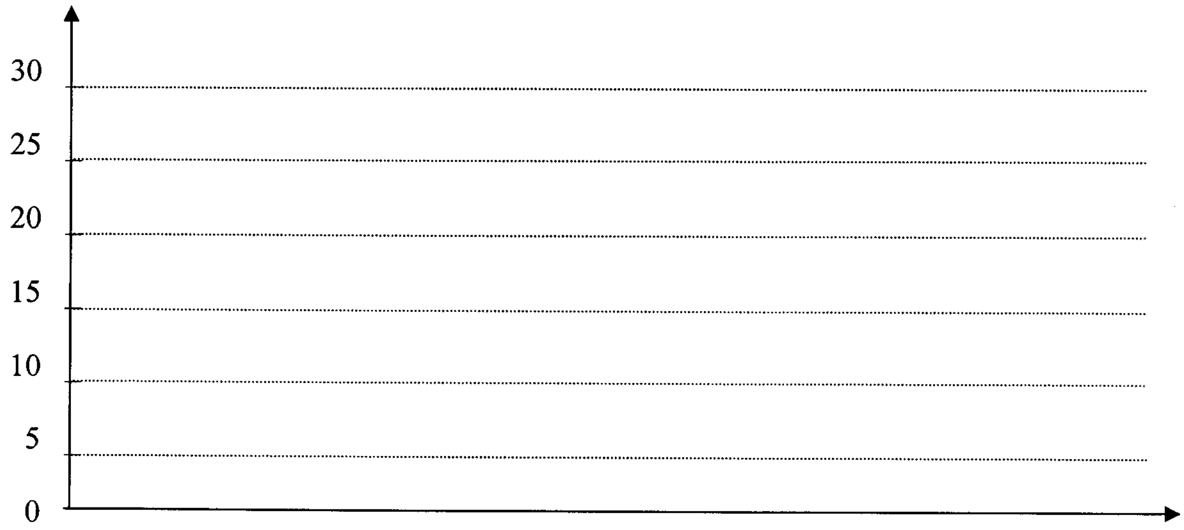
Midterm examination : Semester 2
Course : Digital Image Processing (240-332)
Duration : 2 hours

Academic year : 2004 – 2005
Date : December 20th

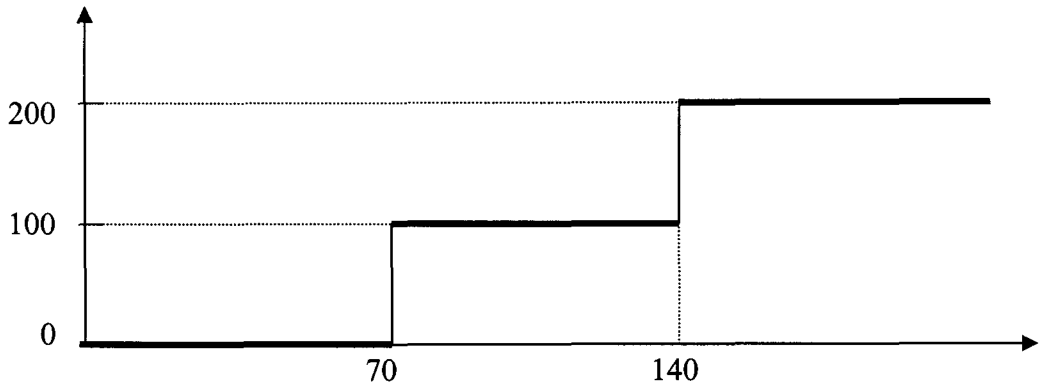
Let's consider the following image f (x, y) which has 9 rows and 9 columns and 256 gray levels for each pixel :

0	0	0	0	0	0	0	0	0
0	100	110	90	95	105	100	100	0
0	100	110	105	110	110	110	100	0
0	100	105	110	115	110	110	110	0
0	100	100	110	160	115	115	115	0
0	110	110	110	115	115	110	110	0
0	115	110	110	110	110	100	100	0
0	115	115	110	110	100	80	80	0
0	0	0	0	0	0	0	0	0

1. Compute the histogram of the image f (x, y). (3 points)
(Answer the question on the following drawing)

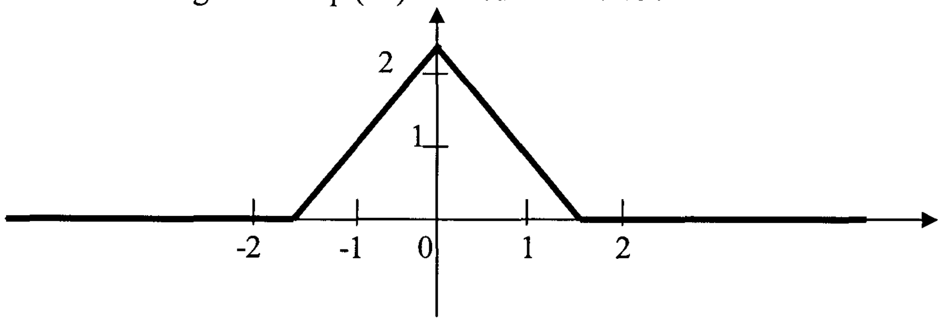


2. We want to apply a gray level transformation to the image f (x, y) to obtain a new image g (x, y).
The gray level transformation is defined by the following function :



Compute the new image g (x, y) in the following array. (2 points)

3. We consider the following function p (x) defined as follows :



Give a 3 x 1 discrete mask to approximate this function. (3 points)

4. We consider the following 3 x 3 discrete mask m (x, y) :

$$m(x, y) = \frac{1}{10}$$

1	1	1
1	2	1
1	1	1

Compute a new image h (x, y) which is obtained by the convolution of g (x, y) and m (x, y) :

$$h(x, y) = g(x, y) \otimes m(x, y)$$

Draw the new image h (x, y) in the following array. (4 points)

5. We consider now a 5 x 5 image i (x, y).

1	3	4	2	1
2	8	9	25	3
10	15	32	28	27
27	33	25	20	12
19	21	25	21	19

Apply a 3 x 3 median filter to the image i (x, y) to obtain a new image j (x, y) and draw j (x, y) in the following array : (4 points)

6. Suppose that a flat surface with center at (x_0 , y_0) is illuminated by a light source with intensity distribution $i (x, y)$ given by :

$$i (x, y) = K e^{Y} \qquad \text{with} \qquad Y = - [(x - x_0)^2 + (y - y_0)^2]$$

The reflectance of the surface is given by :

$$r (x, y) = 20 + 10 (x - x_0) + 10 (y - y_0)$$

a. What is the value of $f (x_0+1 , y_0+1)$? (1 point)

b. What is the value of K that would give an image intensity equal to 100 at the pixel (x_0, y_0) ? (1 point)

7. A Gaussian function P (x) with mean μ and variance σ^2 is defined by :

$$P(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-(x-\mu)^2/(2\sigma^2)}$$

When $\mu = 0$, we denote the Gaussian function with variance σ^2 , by g (x) , and its Fourier transform is :

$$F_g(u) = \exp(-2\pi^2\sigma^2u^2) \qquad \text{where } \exp(y) = e^y$$

Let f (x) be a function and $F_f(u)$ its Fourier transform.

We compute n times the convolution of the function f (x) by the Gaussian g (x) with variance σ^2 :

$$((\ldots((f(x) \otimes g(x)) \otimes g(x)) \otimes \ldots) \otimes g(x)) \qquad (\text{n times})$$

or

$$f(x) \otimes g(x) \otimes g(x) \otimes \ldots \otimes g(x) \qquad (\text{n times})$$

By using the convolution theorem, find the Gaussian function h (x) such that : (2 points)

$$f(x) \otimes h(x) = f(x) \otimes g(x) \otimes g(x) \otimes \ldots \otimes g(x) \quad (\text{n times})$$

(that is : find the Gaussian function equivalent to n convolutions by the function g (x))

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