2.6* A CCD camera chip of dimensions 7×7 mm and 1024×1024 sensing elements, is focused on a square, flat area, located 0.5 m away. The camera is equipped with a 35-mm lens. How many line pairs per mm will this camera be able to resolve? (*Hint:* Model the imaging process as in Fig. 2.3, with the focal length of the camera lens substituting for the focal length of the eye.)

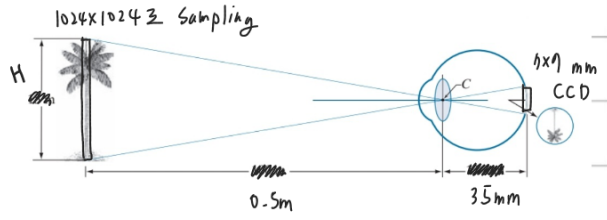


FIGURE 2.3 Graphical representation of the eye looking at a palm tree. Point C is the focal center of the lens.

0.5m = 500mm

H : 500 = 7 : 35

H = 100 mm

100 X 100mm 의 이미지를 1024X1024로 샘플링 해야 하므로, 1mm당 약 10.24개, 반올림하면 10개를 가진다. (10 line/mm)

이때 단위는 line pairs/mm 이므로, 답은 5 line pairs/mm 이다.

2.9 A common measure of transmission for digital data is the *baud rate*, defined as symbols (bits in our case) per second. As a minimum, transmission is accomplished in packets consisting of a start bit, a byte (8 bits) of information, and a stop bit. Using these facts, answer the following:

(a)* How many seconds would it take to transmit a sequence of 500 images of size 1024×1024 pixels with 256 intensity levels using a 3 M-baud (10^6 bits/sec) baud modem? (This is a representative medium speed for a DSL (Digital Subscriber Line) residential line.

(b) What would the time be using a 30 G-baud (10^9 bits/sec) modem? (This is a representative medium speed for a commercial line.)

(a) $500 \times (1024 \times 1024)$ bits $/ (3 \times 10^6$ bits/s)

= 174.763 seconds

(b) $500 \times (1024 \times 1024)$ bits $/ (30 \times 10^9$ bits/s)

= 0.01748 second

2.10* High-definition television (HDTV) generates images with 1125 horizontal TV lines interlaced (i.e., where every other line is "painted" on the screen in each of two fields, each field being 1/60th of a second in duration). The width-to-height aspect ratio of the images is 16:9. The fact (that the number of horizontal lines is fixed) determines the vertical resolution of the images. A company has designed a system that extracts digital images from HDTV video. The resolution of each horizontal line (in their system) is proportional to vertical resolution of HDTV, with the proportion being the width-to-height ratio of the images. Each pixel (in the color image) has 24 bits of intensity, 8 bits each for a red, a green, and a blue component image. These three "primary" images form a color image. How many bits would it take to store the images extracted from a two-hour HDTV movie?

vertical : 1125 - height pixels

1125 x (16:9) = 125 x 16

= 2000 - width pixels

24 x (2000 x 1125) x 2 x 60 x 60

= 388.8G bits

2.12* Suppose that a flat area with center at (x_0, y_0) is illuminated by a light source with intensity distribution

$$i(x,y) = Ke^{-[(x-x_0)^2 + (y-y_0)^2]}$$

Assume for simplicity that the reflectance of the area is constant and equal to 1.0, and let $K = 255$. If the intensity of the resulting image is quantized using k bits, and the eye can detect an abrupt change of eight intensity levels between adjacent pixels, what is the highest value of k that will cause visible false contouring?

8단계 변화

level별 픽셀값 증가량

$\frac{256}{2^k} > 8$ → false contouring

$2^k < \frac{256}{8} = 32$

$k < 5$

인접 픽셀에서 이만큼 색만차이나도 false contouring 보임

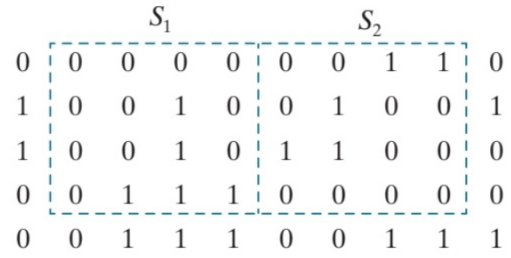
0 32 64 96 128 160 192 224 256

2.14 Consider the two image subsets, S_1 and S_2 in the following figure. With reference to Section 2.5, and assuming that $V = \{1\}$, determine whether these two subsets are:

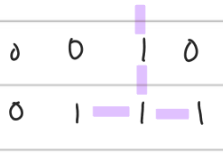
(a)* 4-adjacent.

(b) 8-adjacent.

(c) m-adjacent.

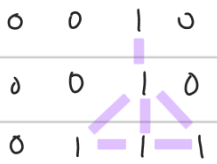


(a) S_1 : 4-adjacency 성립

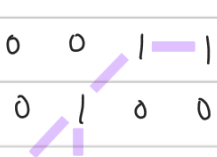


S_2 : 4-adjacency 성립 X

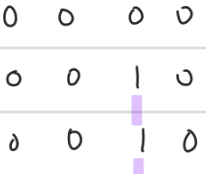
(b) S_1 : 8-adjacency 성립



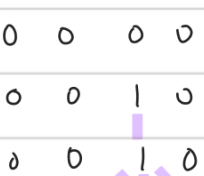
S_2 : 8-adjacency 성립 X



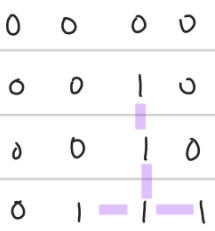
(c) S_1 : 각 픽셀의 N_4를 구한 후 N_D를 구하여 합칩니다.



S_1 : N_D를 구하여 합친 그래프에서 N_4끼리 교집합을 가지는 픽셀의 N_D를 제거합니다.

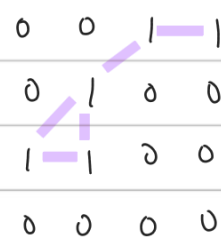


S_1 : S_1의 m-adjacency는 다음과 같습니다.

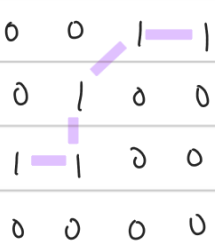


S_2 : 각 픽셀의 N_4를 구한 후 N_D를 구하여 합칩니다.

S_2 : N_D를 구하여 합친 그래프에서 N_4끼리 교집합을 가지는 픽셀의 N_D를 제거합니다.



S_2 : S_2의 m-adjacency는 다음과 같습니다.



2.22* In the next chapter, we will deal with operators whose function is to compute the sum of pixel values in a small subimage area, S_{xy}, as in Eq. (2-43). Show that these are linear operators.

$$g(x,y) = \frac{1}{mn} \sum_{(r,c) \in S_{xy}} f(r,c) \qquad (2\text{-}43)$$

$$\sum_{(r,c) \in S_{xy}} f(r,c) = \sum f(x,y)$$

$$g(f(x,y)) = \frac{1}{mn} \sum f(x,y)$$

$$g(a f_1(x,y) + b f_2(x,y))$$

$$= a\, g(f_1(x,y)) + b\, g(f_2(x,y))$$

$$\Rightarrow g(a f_1(x,y) + b f_2(x,y))$$

$$= \frac{a}{mn} \sum f_1(x,y) + \frac{b}{mn} \sum f_2(x,y)$$

$$a\, g(f_1(x,y)) + b\, g(f_2(x,y))$$

$$= \frac{a}{mn} \sum f_1(x,y) + \frac{b}{mn} \sum f_2(x,y)$$

$\therefore$ 선형성 성립

2.24 The median, ζ, of a set of numbers is such that half the values in the set are below ζ and the other half are above it. For example, the median of the set of values {2,3,8,20,21,25,31} is 20. Show that an operator that computes the median of a subimage area, S, is nonlinear. (*Hint:* It is sufficient to show that ζ fails the linearity test for a simple numerical example.)

$S_1 = \{1, -2, 3\}$, $S_2 = \{4, 5, 6\}$ 이고

중앙값 ζ을 찾는 함수를 $H(S)$ 라고 할 때,

$H(S_1+S_2) = H(S_1) + H(S_2)$ 이 성립하면

linear 하다.

$H(S_1+S_2) = H(\{5, 3, 9\}) = 5$

$H(S_1)+H(S_2) = H(\{1,-2,3\}) + H(\{4,5,6\})$

$= 1+5 = 6$

$\therefore H(S_1+S_2) \neq H(S_1)+H(S_2)$

$\Rightarrow$ non-linear

. . .

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