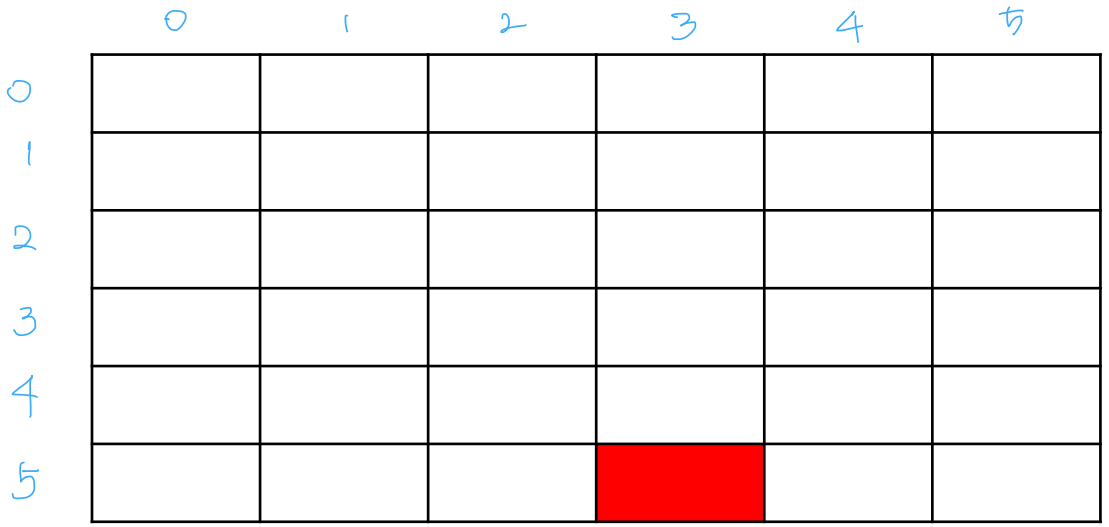
Exercise 1

Sung Soo Hwang

Exercise 1

- What is the x coordinate and y coordinate of the pixel marked in red?



(3, 5)

Exercise 1

- Suppose you have a 3 channel color video whose specification is described below. Calculate the amount of bytes we need to save the video without compression
  - Pixel resolution is UHD
  - 60fps
  - Intensity level is 1024
  - Total length is 30 minutes

10 bits / color x 3 colors / pixel x (3840 x 2160 pixels) / frame x 60 frames / second x 1800 seconds / hour ≈ 300 GB

Exercise 1

- Suppose you want to display a video two times faster. If the frame rate of the video is denoted as fps, what should be the parameter for waitKey() function?

1000 / 2fps ⇒ 500 /fps

Exercise 1

- Write a code that declares a matrix whose name is ‘test’, and the size of matrix is VGA, and the pixel type is 3 channel, 8-bit unsigned. Also, initialize the pixel as green.

```
cv:: Mat test (480, 640, CV_8UC3, Scalar (0, 255, 0));
```

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Exercise 2

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Exercise 2

- Write a code that access the pixel in red if the image is a 1-channel image.

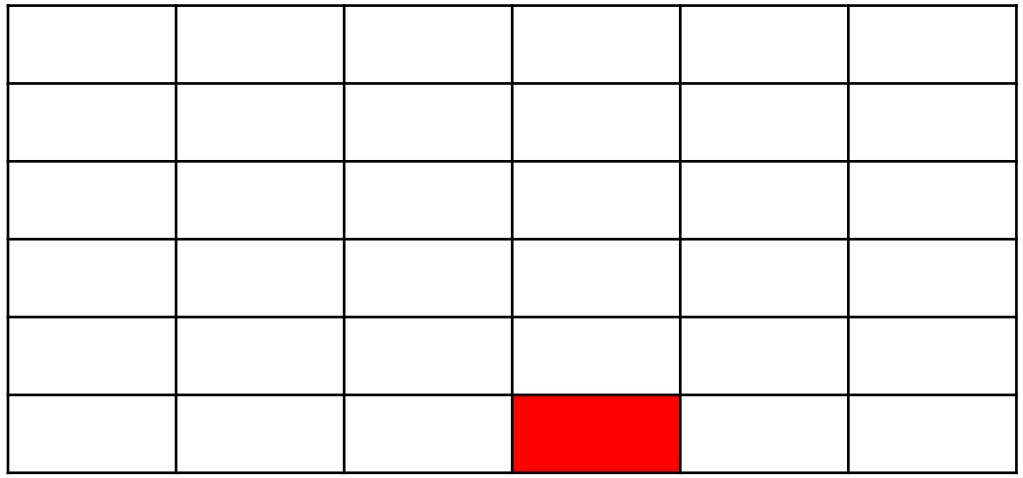

Image.at<uchar>(5,3)

Exercise 2

- Write a code that generates a upside-down image. Assume that the input image is a 1-channel image, and the name of the input image is ‘test2’. And the width and the height of ‘test2’ are ‘w’ and ‘h’, respectively. The name of the generated image is ‘test2_upsidedown’.

```
for (int j=0; j<h; j++)
    for (int i=0; i<w; i++)
        test2_upsidedown.at<uchar>(h-j-1, i) = test2.at<uchar>(j, i);
```

Exercise 2

- When the image was taken in a very dark place, what should be the value of gamma for gamma correction to enhance the image?

Set the value of gamma to less than 1.

Exercise 2

- Suggest an algorithm which determines the value of gamma for gamma correction to enhance the input image

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Exercise 3

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Exercise 3

- What would be the value of the pixel in red after applying a spatial filtering with the given kernel?

5	5	5	5	5	5
10	10	10	10	10	10
15	15	15	15	15	15
20	20	20	35	20	20
25	25	25	25	25	25
30	30	30	30	30	30

0	1/3	0
0	1/3	0
0	1/3	0

$(10\times0)+(10\times\frac{1}{3})+(10\times0)$

$+(15\times0)+(15\times\frac{1}{3})+(15\times0)$

$+(20\times0)+(35\times\frac{1}{3})+(20\times0)$

$=\frac{10+15+35}{3}=\frac{60}{3}=20.$

Exercise 3

- What would be the value of the pixel in red after applying a median filtering with the mask size of 3X3?

1	2	3	4	5	6
12	11	15	16	17	7
13	14	10	9	8	18
24	23	22	21	20	19
25	25	25	25	25	25
30	30	30	30	30	30

[8, 9, 10, 15, 16, 17, 20, 21, 22]

<16>

Exercise 3

- What would be the value of a matrix as a result of applying absdiff() on matrix A and matrix B?

A

1	2	3	4
12	11	15	16
13	14	10	9
24	23	22	21

B

21	22	23	24
16	15	11	12
13	14	10	9
4	3	2	1

$$\begin{bmatrix} 20 & 20 & 20 & 20 \\ 4 & 4 & 4 & 4 \\ 0 & 0 & 0 & 0 \\ 20 & 20 & 20 & 20 \end{bmatrix}$$

Exercise 3

- What would be the elements of ‘rect_roi’ when a ROI of the input matrix is given as follows?

```
Rect rect(2,1,3,4);
Mat rect_roi = image(rect);
```

5	5	5	5	5	5
10	10	10	10	10	10
15	15	15	15	15	15
20	20	20	35	20	20
25	25	25	25	25	25
30	30	30	30	30	30

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Exercise 4

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Exercise 4

- Compute a normalized histogram for the input image. Assume dynamic range of the input is from 0~31, and the number of bins is 8.

32 / 8 = 4.

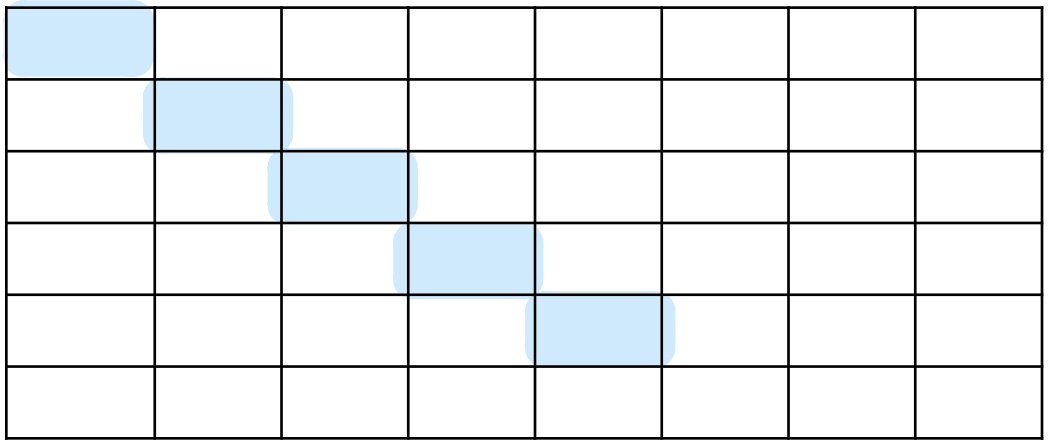
0	1	2	3	4	5	6	7
8	9	10	11	12	13	14	15
16	17	18	19	20	21	22	23
24	25	26	27	28	29	30	31
24	25	26	27	28	29	30	31
24	25	26	27	28	29	30	31

[0~3] 0, 1, 2, 3 $\frac{4}{48}$
[4~7] 4, 5, 6, 7 "
[8~11] 8, 9, 10, 11 "
[12~15] 12, 13, 14, 15 "
[16~19] 16, 17, 18, 19 "
[20~23] 20, 21, 22, 23 "
[24~27] 24, 25, 26, 27 $\frac{12}{48}$
[28~31] 28, 29, 30, 31 "

Exercise 4

- Mark a pixel in red when the pixel is the part of the line defined as below.

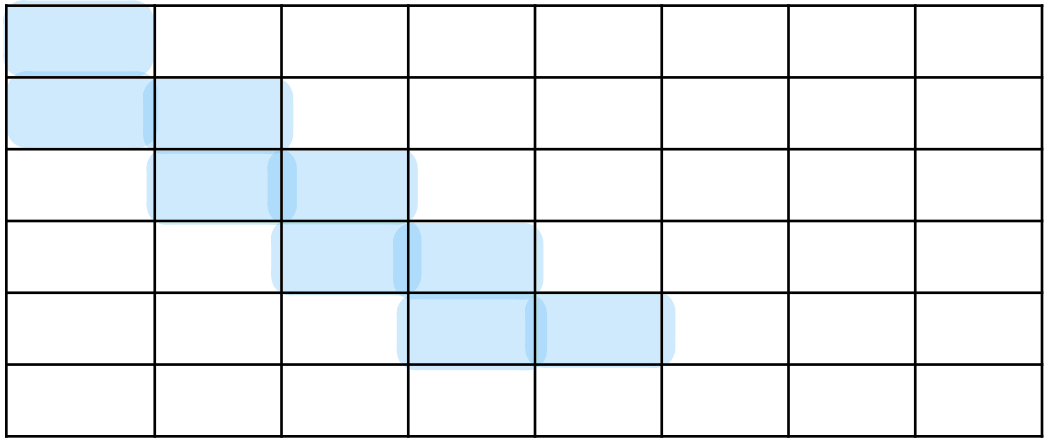
```
Point p1(0, 0), p2(4,4);
line(image, p1, p2, Scalar(0, 0, 255), 1, 8, 0);
```



Exercise 4

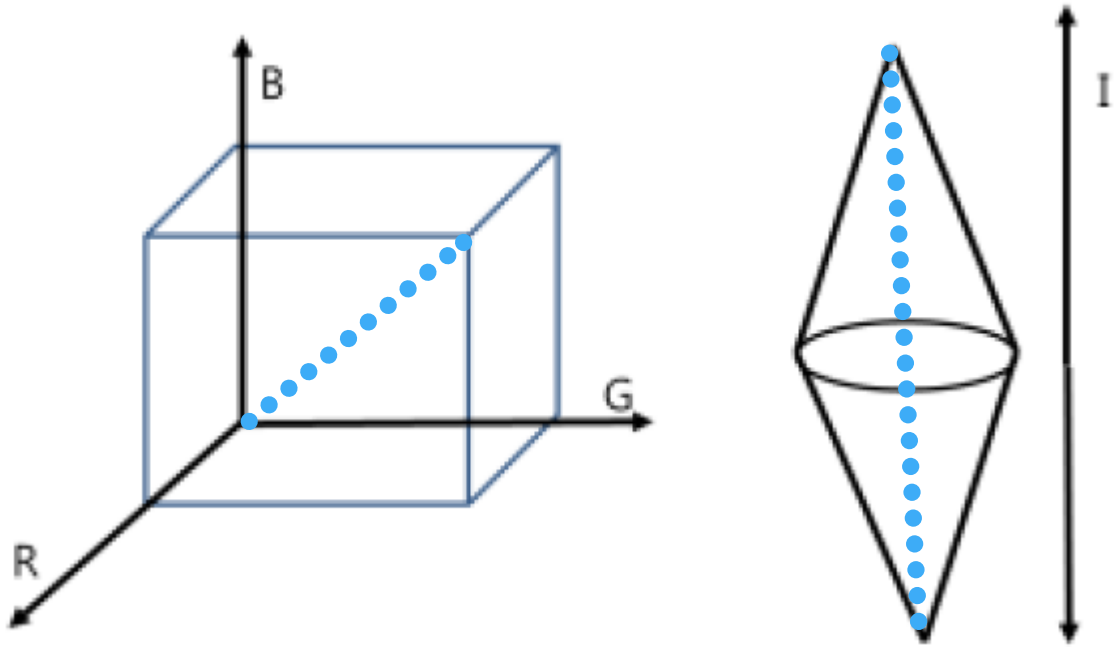
- Mark a pixel in red when the pixel is the part of the line defined as below.

```
Point p1(0, 0), p2(4,4);
line(image, p1, p2, Scalar(0, 0, 255), 1, 4, 0);
```



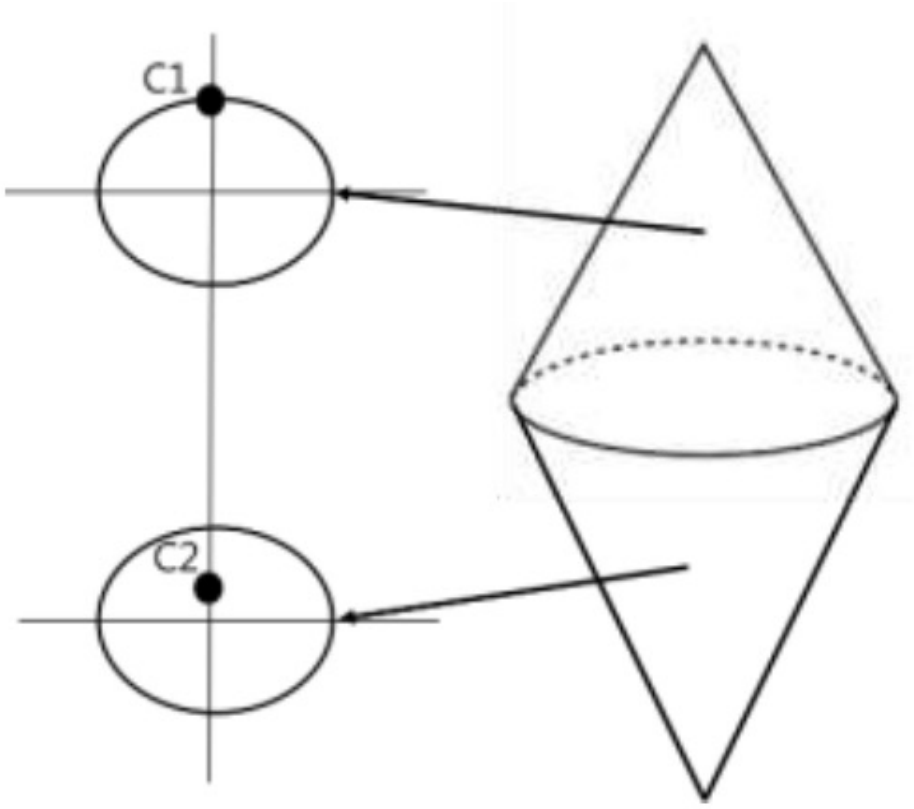
Exercise 4

- Mark the location of achromatic color in the following RGB space and HSI space



Exercise 4

- Compare Hue, Saturation, and Intensity value of C1 and C2.



Hue: $C_1 = C_2$

Saturation: $C_1 > C_2$

Intensity: $C_1 > C_2$

Exercise 4

- Perform white balancing of the image below using gray-world assumption. Assume dynamic range of the input is from 0~31

0	1 1.006	2 2.012	3 3.018
8 8.048	9 9.054	10 10.06	11 11.066
16 16.096	17 17.102	18 18.108	19 19.114
24 24.114	25 25.15	26 26.156	27 27.162
24 24.114	25 25.15	26 26.156	27 27.162

⇒ 1602 정.

전체평균: 15.9

⇒ 각 pixel x $\frac{16}{15.9}$

Exercise 5

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Exercise 5

How should we change 3rd and 4th parameter to obtain fewer (more accurate edges) edges?

Void Canny(InputArray image, OutputArray edges, double threshold1, double threshold2, int apertureSize=3, bool L2gradient = false)

threshold 1 & 2 ↑ (should be increased)

Exercise 5

How should we change the 5th parameter to obtain more lines?

void HoughLines(InputArray image, OutputArray lines, double rho, double theta, int threshold, double srn=0, double stn=0)

threshold ↓

(should be decreased)

Exercise 5

We are going to perform edge linking using Hough transform. Edge extraction is already done, and there exist N edge points in a binary image. We subdivide ρθ-space into accumulator cells by Y and X sections, respectively. Then, what is the maximum value that accumulator cells can have after the Hough transform?

Answer:

i) We can make XY lines for each edge pixel. There are NXY visits at the accumulator cells.

ii) the maximum value that accumulator cells can have is N if all edge pixels lay on the same line.

모든 edge pixel마다 XY개의 직선 생성 → NXY번 방문.

해결 방법

- **핵심 개념**:
  - 허프 변환에서는 모든 에지 포인트가 ρ-θ 공간에서 특정 궤적(곡선)에 기여.
  - 하나의 셀에 에지 포인트가 가장 많이 모이는 경우가 최대값.
- **계산**:
  - 각 에지 포인트가 최대한 같은 셀에 기여한다고 가정.
  - N개의 에지 포인트가 모두 하나의 셀에 포함되는 것이 누적 셀의 최대값.

Exercise 5

Obtain the magnitude of gradient of the pixels in bold in the input image by using two kinds of Sobel mask. When you calculate magnitude of gradient, use mag(∇f)=|g_x |+|g_y |.

Input

5	5	5	5	5
10	**10**	**10**	10	10
10	**10**	**10**	10	10
10	10	10	10	10
15	15	15	15	15

Sobel mask1 세로 (y)

-1	-2	-1
0	0	0
1	2	1

⇒ −5 −10 −5 / 0 0 0 / 10 20 10 → Sum = 20.

g_y: 20 20 / 0 0

Sobel mask 2 가로(x)

-1	0	1
-2	0	2
-1	0	1

⇒ −5 0 5 / −20 0 20 / −10 0 10 → Sum = 0

g_x: 0 0 / 0 0

⇒ ∇f: 20 20 / 0 0

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Exercise 6

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Exercise 6

Calculate the thresholding result when the following function is executed

threshold(Input, Result, 195,200,THRESH_BINARY)

Input

10	30	170	180
30	50	210	220
230	240	160	180
250	250	170	180

If 195 ↓ : 0

195 ↑ : 200

Result

0	0	0	0
0	0	200	200
200	200	0	0
200	200	0	0

Exercise 6

Calculate the thresholding result when the following function is executed

threshold(Input, Result, 127,255, THRESH_TOZERO)

Input

10	30	170	180
30	50	210	220
230	240	160	180
250	250	170	180

Result

0	0	170	180
0	0	210	220
230	240	160	180
250	250	170	180

Exercise 6

Calculate the thresholding result for the pixel in red when the following function is executed

adaptiveThreshold(input,Result, 255, ADAPTIVE_THRESH_MEAN_C, THRESH_BINARY, 3, 5);

Input

3X3 영역

10	30	170	180
30	50	210	220
230	240	160	180
250	250	170	180

210+290+630 = 1130

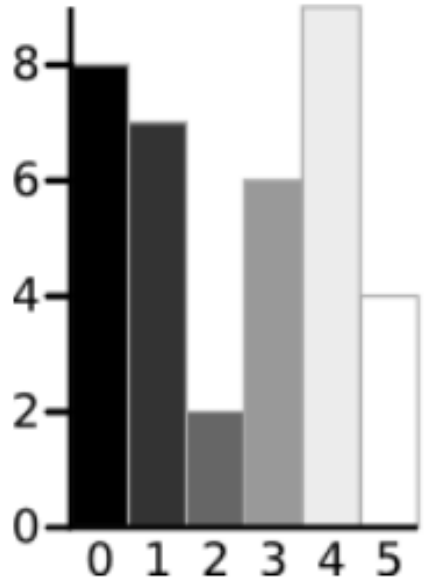
$\frac{1130}{9} = 125.6$

125.6 - 5 = 120.6

50 < 120.6 ⇒ 0

Exercise 6

Calculate the within-class variance when the threshold is set to 3. So, class 1 is consists of pixels with the value of 0~2 and class 2 consists of pixels with the value of 3~5



http://www.labbookpages.co.uk/software/imgProc/otsuThreshold.html

Class 1: $\frac{0\cdot 8+1\cdot 7+2\cdot 2}{8+7+2} = 0.6421$

$\frac{(0-0.6)^2\cdot 8+(1-0.6)^2\cdot 7+(2-0.6)^2\cdot 2}{8+7+2} = 0.4637$

$W = \frac{8+7+2}{8+7+2+6+9+4} = 0.4722 \left(\frac{17}{36}\right)$

Class 2: $\frac{3\cdot 6+4\cdot 9+5\cdot 4}{6+9+4} = 3.8947$

$\frac{(3-0.6)^2\cdot 6+(4-0.6)^2\cdot 9+(5-0.6)^2\cdot 4}{6+9+4} = 0.5152$

$W = \frac{6+9+4}{8+7+2+6+9+4} = 0.5278 \left(\frac{19}{36}\right)$

→ Within class variance: 0.4909 ← $\frac{17}{36}\cdot 0.464+\frac{19}{36}\cdot 0.515$

Exercise 7

Sung Soo Hwang

Exercise 7

Assume you have a background image on the left. Perform pixel-based background subtraction to the image on the right with threshold as 10. For pixels corresponding to moving object, set those pixels as 255. Set other pixels as 0.

1	1	1	1
1	1	1	1
1	1	1	1
1	1	1	1

5	6	7	8
10	12	12	13
15	16	17	18
20	21	22	23

Answer

0	0	0	0
0	255	255	255
255	255	255	255
255	255	255	255

Exercise 7

Perform erosion and dilation on the input image by using the following structure element

Input

0	0	0	0	0
0	0	1	0	0
0	1	1	1	0
0	0	1	0	0
0	0	0	0	0

Structure element

0	1	0
1	1	1
0	1	0

Answer

erosion

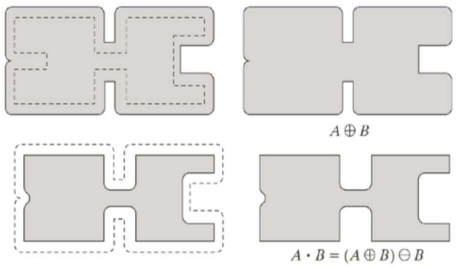
0	0	0	0	0
0	0	0	0	0
0	0	1	0	0
0	0	0	0	0
0	0	0	0	0

dilation

0	0	1	0	0
0	1	1	1	0
1	1	1	1	1
0	1	1	1	0
0	0	1	0	0

Exercise 7

Suppose you have a binary object A on the left. And you applied morphological operation (opening or closing) and the result is shown on the right. Which operation was applied? Explain why.



Answer : [Opening]

Opening smoothens contours, breaks narrow isthmuses, and eliminates small island and sharp peaks