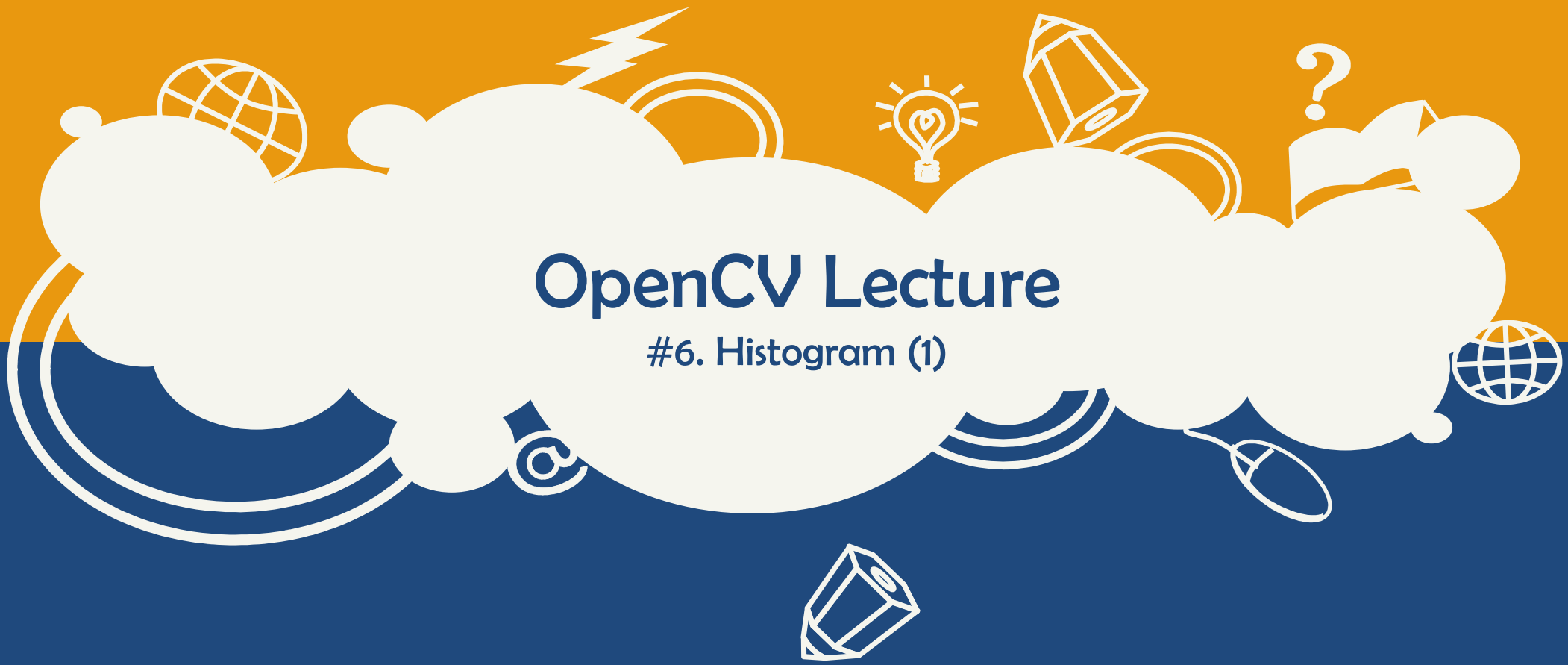


OpenCV Lecture

#6. Histogram (1)

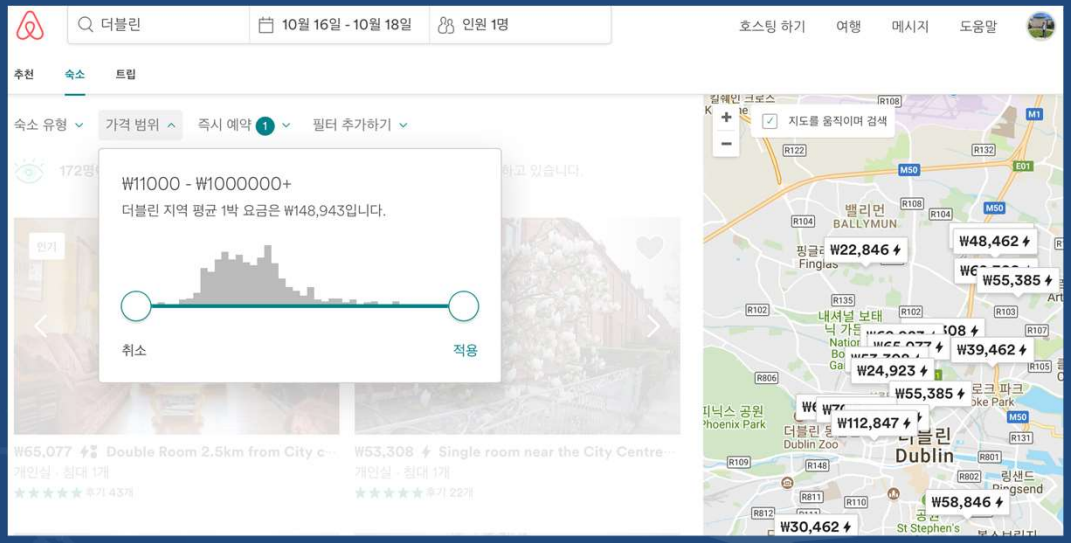
MareArts

Contents

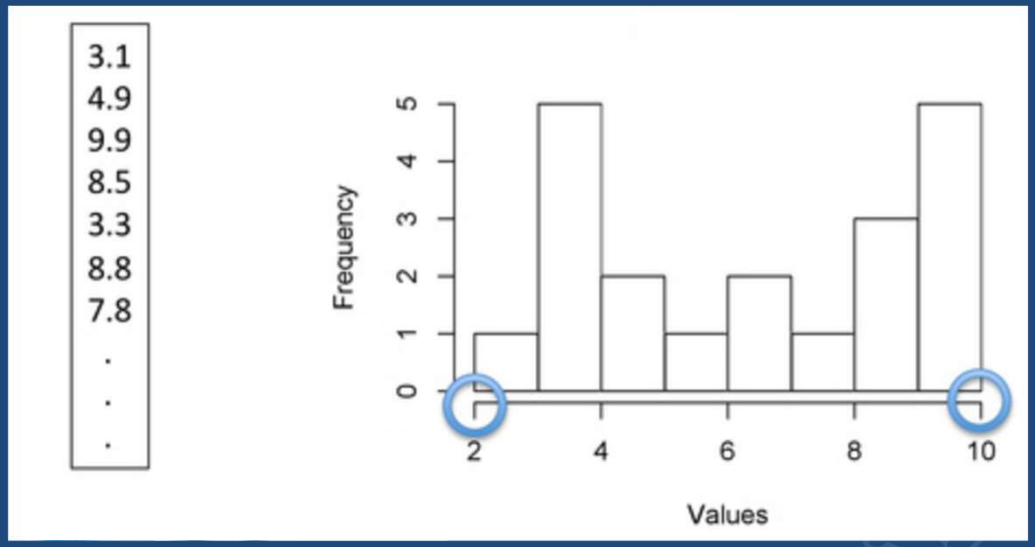
- What is the histogram
- How to make histogram
  - basic
  - graph drawing
- stretch
- equalizes

What is histogram?

- What is the histogram
  - Number within range (in bin).



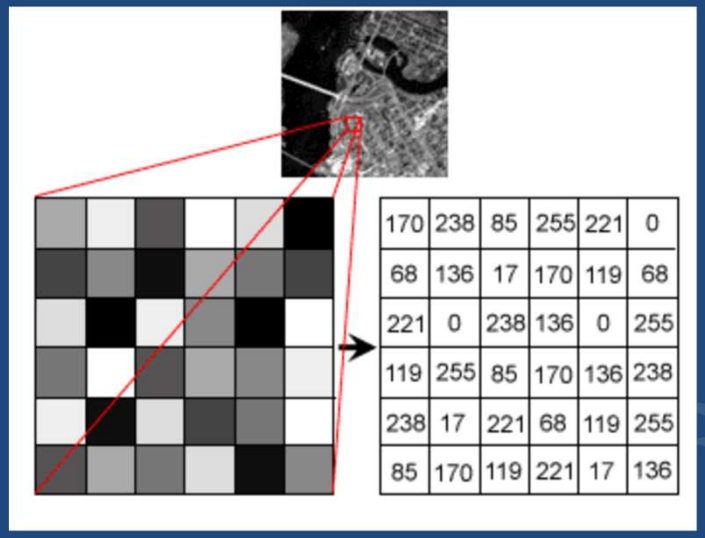
Airbnb

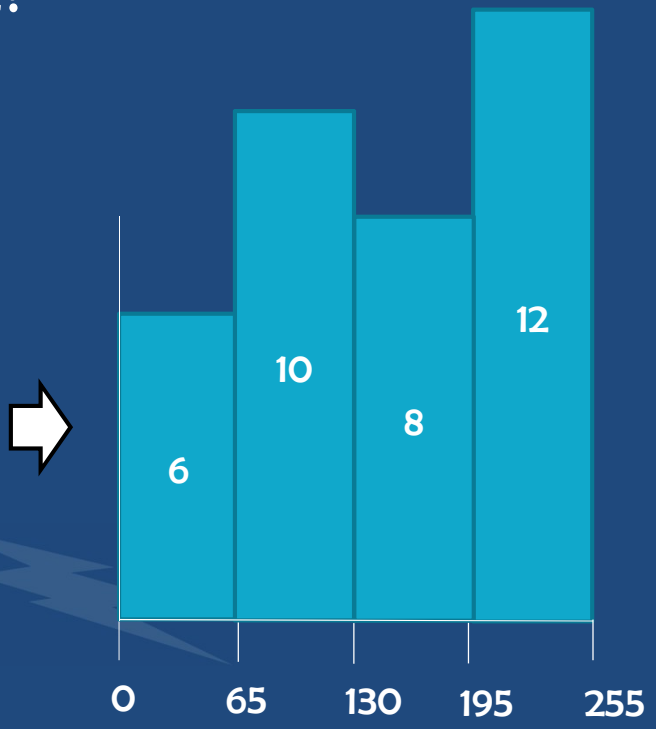


Data and Histogram

What is histogram?

- What is the histogram in image processing?
  - How do we get it?





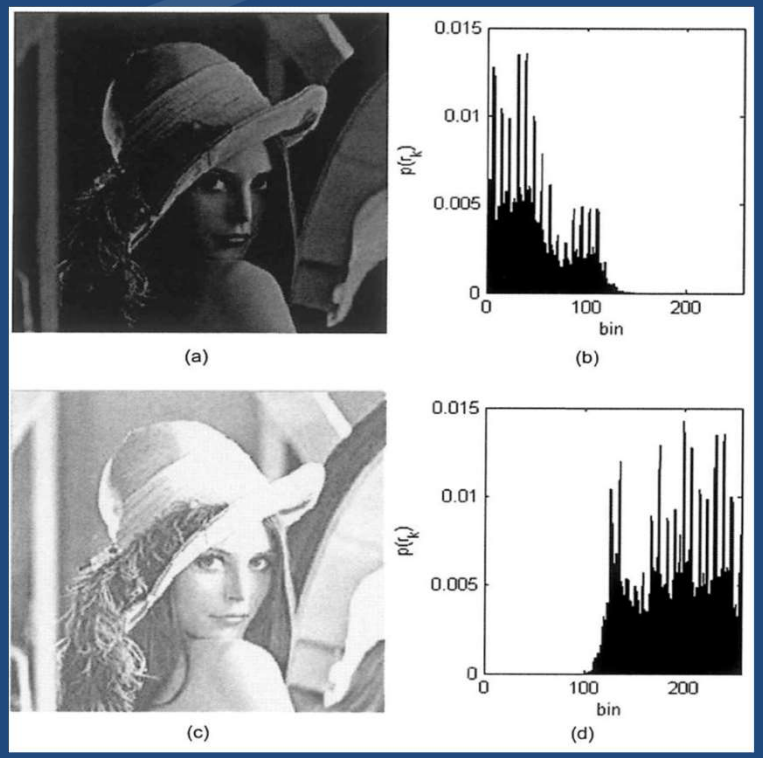


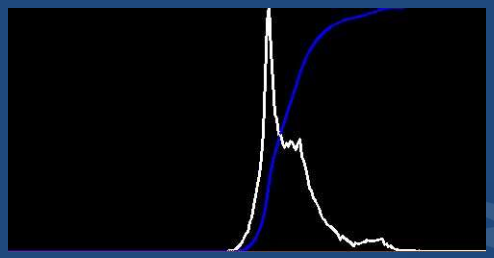
Image analysis and enhancement

- Image analysis

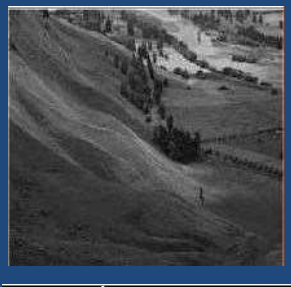
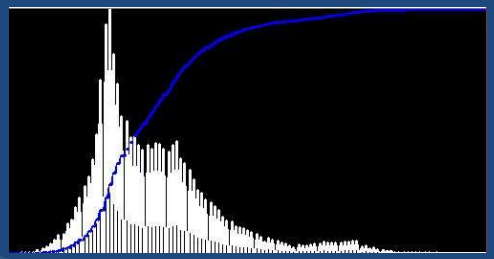
Images from here : https://www.youtube.com/watch?v=2LhfSgrjdGo

Image analysis and enhancement

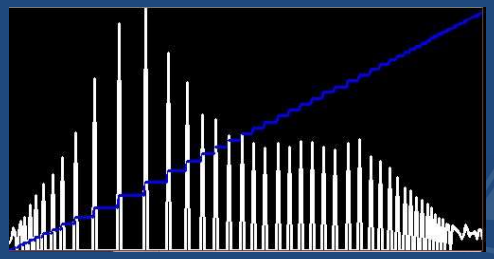
- Image Enhancement
  - Image equalization and stretching introduction

origin

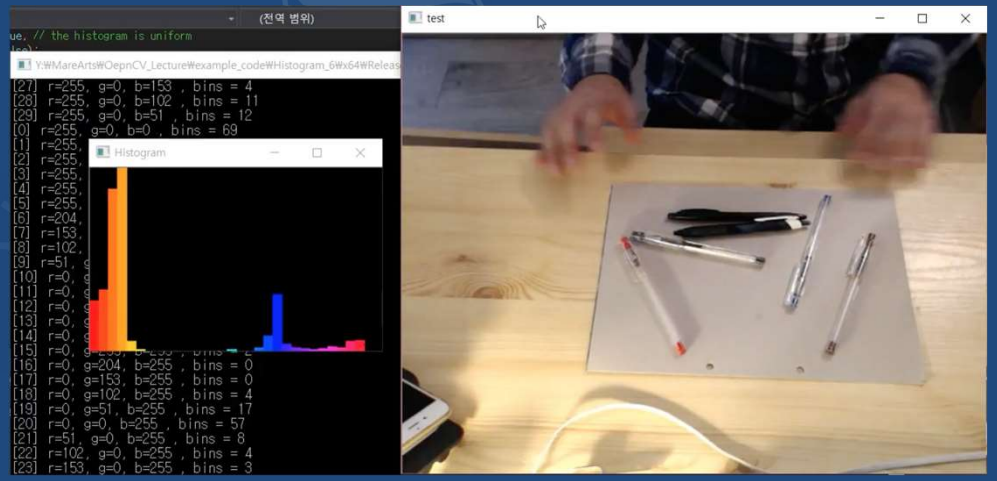
stretching

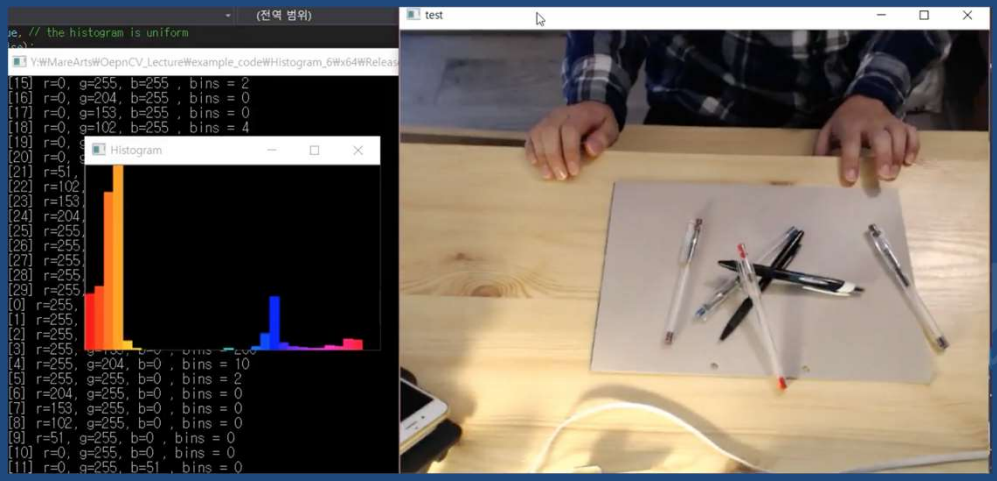



equalization

Advantage of using Histogram

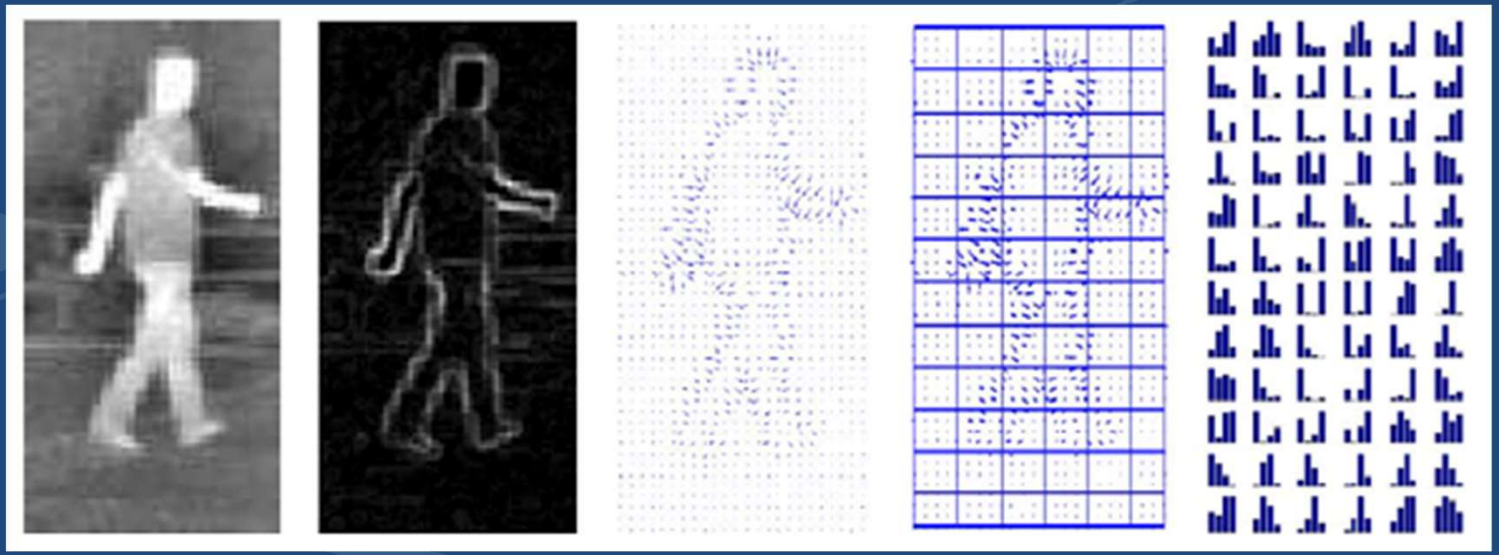
- Feature of histogram?
  - The histogram is similar, even though the position of pens are changed.
    - We can get some invariable feature even when the appearance and position are changed





What else?

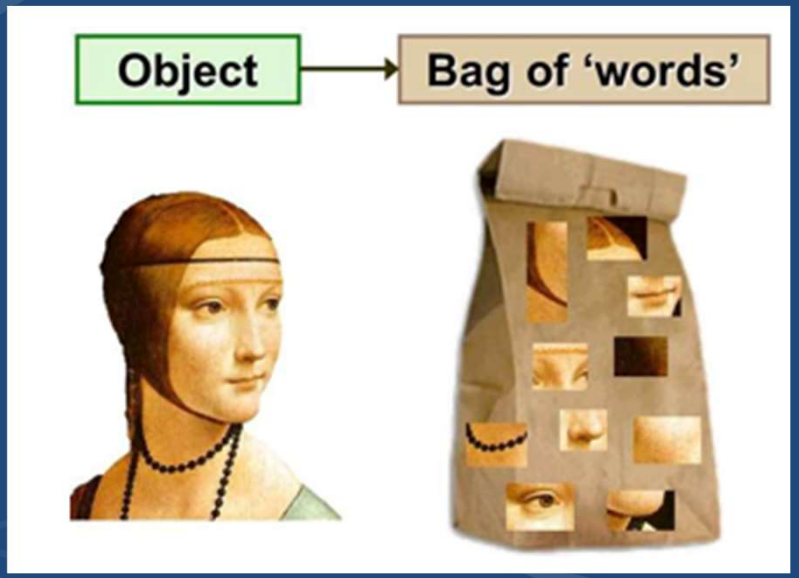
- HOG(Histogram of Oriented Gradient)

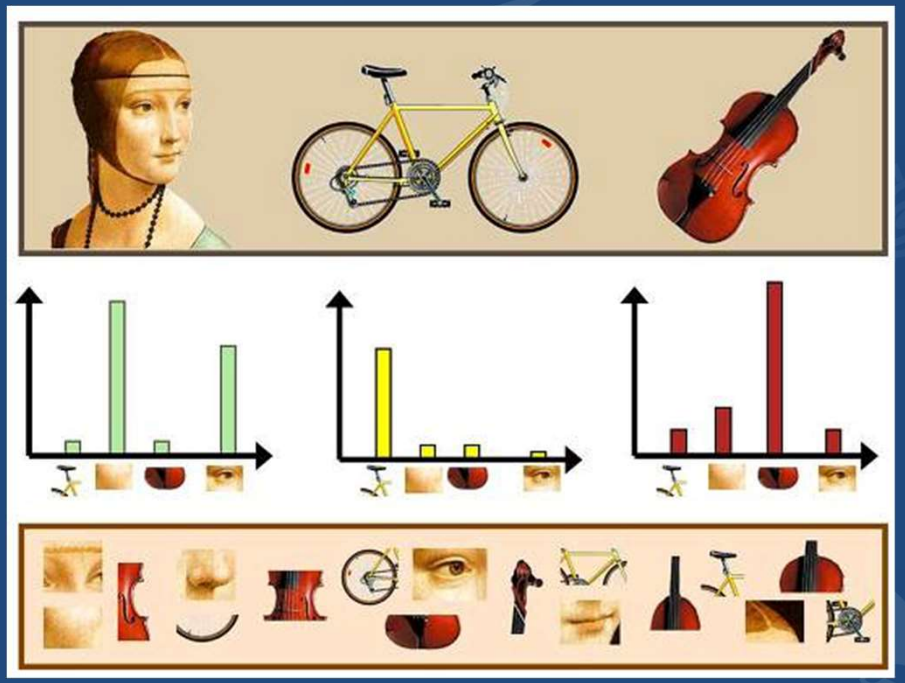


https://www.researchgate.net/figure/232905480_fig4_Fig-8-HOG-concatenates-the-bins-of-the-local-gradient-histograms-into-a-vector-form

What else?

- BOW(Bag Of Words)



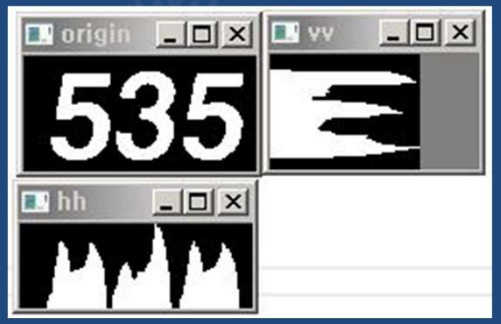


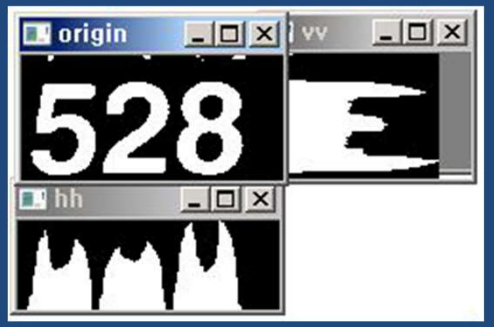
http://people.csail.mit.edu/torralba/shortCourseRLOC/index.html

http://darkpgmr.tistory.com/125

What else?

- Feature





- Matching

similarity 97.58316 %

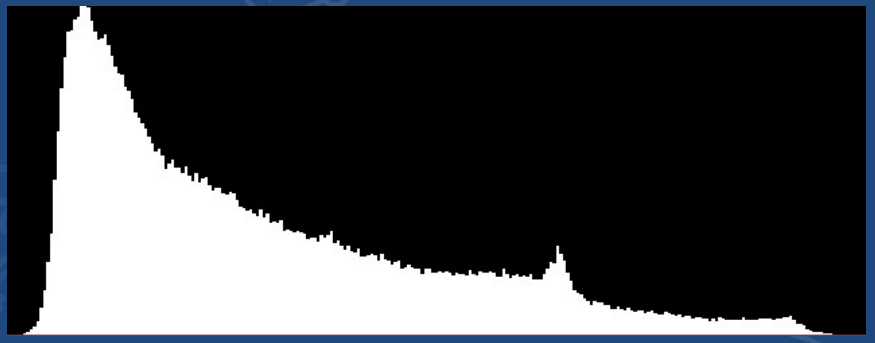
http://study.marearts.com/2013/09/opencv-make-histogram-and-draw-example.html

http://study.marearts.com/2014/11/opencv-emdearth-mover-distance-example.html

http://study.marearts.com/2014/05/open-cv-get-histogram-and-compare-color.html

Let's make a histogram

- Make a histogram without OpenCV function

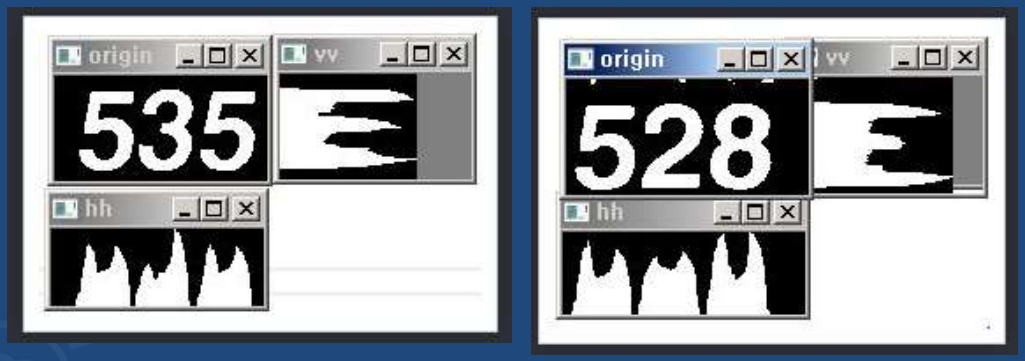


```
//voting
int maxValue = 0;
for (int i = 0; i < gray_img.rows; ++i)
{
        for (int j = 0; j < gray_img.cols; ++j)
        {
                //Vec3b means 'uchar 3ch'
                unsigned char v = gray_img.at<unsigned char>(i, j);
                Histogram_buffer[v] ++;

                if (maxValue < Histogram_buffer[v])
                        maxValue = Histogram_buffer[v];
        }
}
```

Source code : http://study.marearts.com/2017/12/gray-image-histogram-without-opencv.html

Let's make a histogram

- Make a histogram without OpenCV function
  - Refer to another example
    - This is for binary image, it is useful to get some feature.

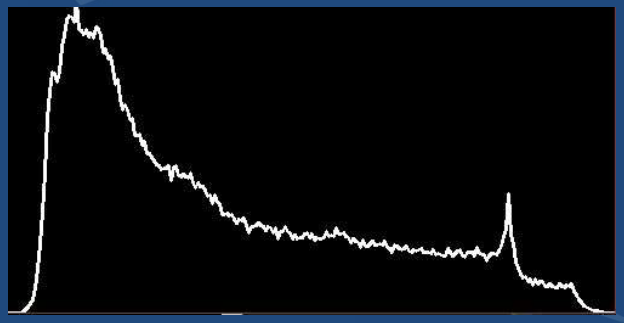


Assignment!!

Source code : http://study.marearts.com/2013/09/opencv-make-histogram-and-draw-example.html

Let's make a histogram

- Make histogram using OpenCV
  - A histogram for gray image



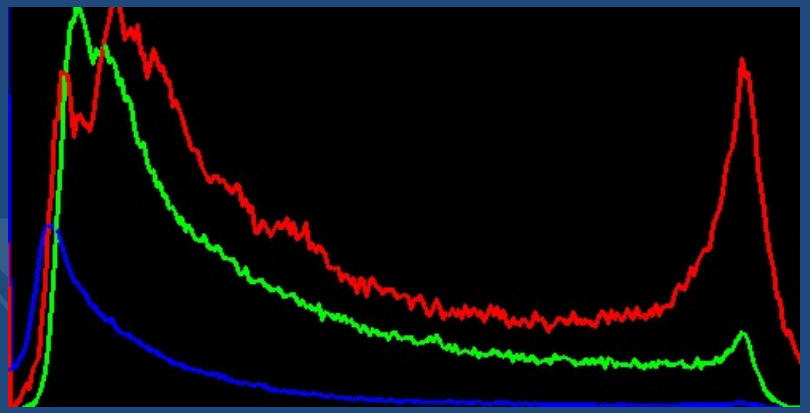
```
int hbins = 255; //histogram x axis size, that is histSize,
                                    //ex) 2 -> 0~128, 129~256, ex)16 -> 0 ~ 15, 16 ~ 31...,
int channels[] = { 0 }; //index of channel
int histSize[] = { hbins };
float hranges[] = { 0, 255 };
const float* ranges[] = { hranges };
```

```
calcHist(&grayImg, 1, channels, Mat(), //MaskForHisto, // // do use mask
        Hist, 1, histSize, ranges,
        true, // the histogram is uniform
        false);
normalize(Hist, Hist, 0, 255, CV_MINMAX);
```

Source code : http://study.marearts.com/2017/12/calhist-for-gray-image-opencv-histogram.html
Reference : https://docs.opencv.org/2.4/modules/imgproc/doc/histograms.html?highlight=calchist#histograms

Let's make a histogram

- Make histogram using OpenCV
  - A histogram for R,G,B



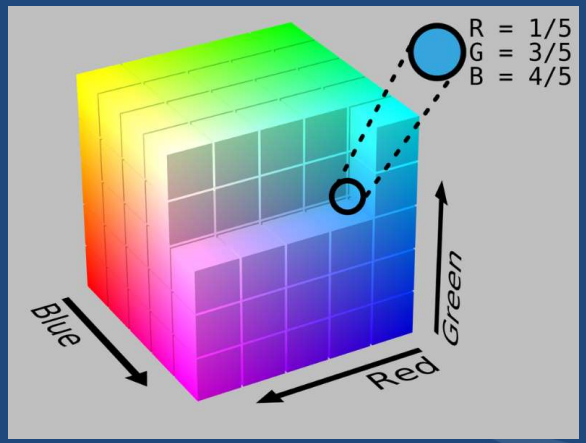
```
//split rgb
vector<Mat> bgr_planes;
split(imgA, bgr_planes);

//cal histogram & normalization
/////////////////////////////////////////////////////////////////////////////////////
calcHist(&bgr_planes[0], 1, 0, Mat(), HistB, 1, histSize, ranges, true, false);
calcHist(&bgr_planes[1], 1, 0, Mat(), HistG, 1, histSize, ranges, true, false);
calcHist(&bgr_planes[2], 1, 0, Mat(), HistR, 1, histSize, ranges, true, false);

normalize(HistB, HistB, 0, 255, CV_MINMAX);
normalize(HistG, HistG, 0, 255, CV_MINMAX);
normalize(HistR, HistR, 0, 255, CV_MINMAX);
```

Source code: http://study.marearts.com/2017/12/calchist-for-rgb-image-opencv-histogram.html

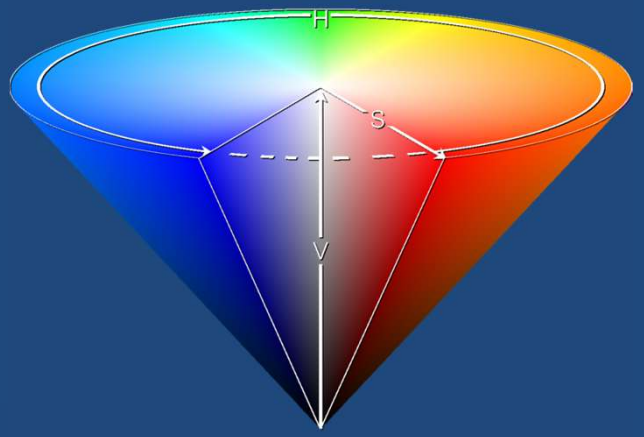
Reference : https://docs.opencv.org/2.4/doc/tutorials/imgproc/histograms/histogram_calculation/histogram_calculation.html

Let's make a histogram

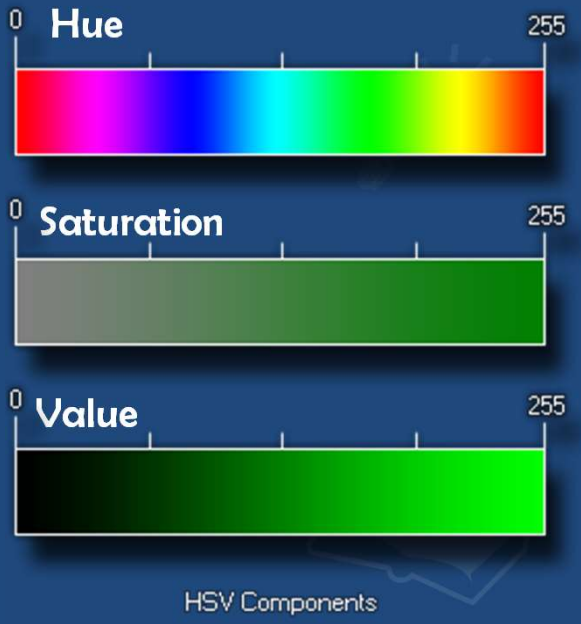
- Make histogram using OpenCV
  - A histogram for HSV
    - What is the HSV?



RGB



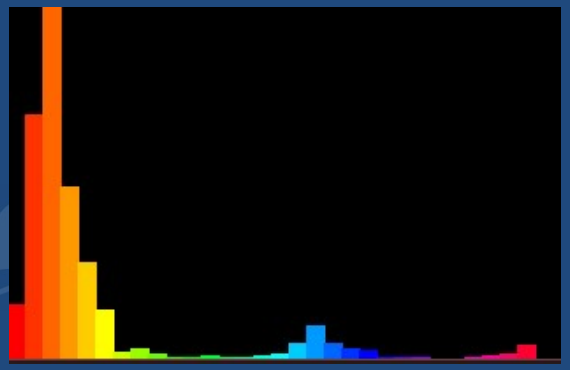
HSV



Reference : https://en.wikipedia.org/wiki/RGB_color_space
https://en.wikipedia.org/wiki/HSL_and_HSV
http://docs.yoyogames.com/source/dadiospice/002_reference/drawing/color%20and%20blending/make_color_hsv.html

Let's make a histogram

- Make histogram using OpenCV
  - A histogram for HSV



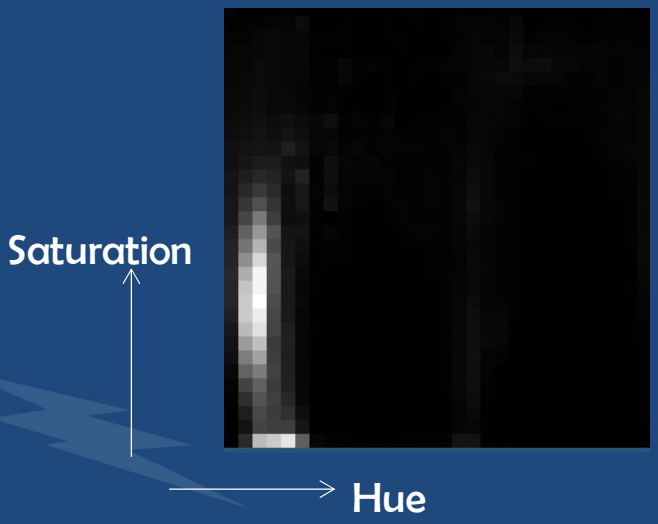
```
int hbins = 30; //histogram x axis size, that is histSize,
//ex) 2 -> 0~128, 129~256, ex)16 -> 0 ~ 15, 16 ~ 31...,
int channels[] = { 0 }; //index of channel
int histSize[] = { hbins };
float hranges[] = { 0, 180 };
const float* ranges[] = { hranges };

Mat patch_HSV;
MatND HistA, HistB;

//cal histogram & normalization
////////////////////////////////////////////////////////////////////////////
cvtColor(imgA, patch_HSV, CV_BGR2HSV);
calcHist(&patch_HSV, 1, channels, Mat(), //MaskForHisto, // // do use mask
        HistA, 1, histSize, ranges,
        true, // the histogram is uniform
        false);
normalize(HistA, HistA, 0, 255, CV_MINMAX);
```

Source code : http://study.marearts.com/2017/12/hue-histogram-example-opencv-source-code.html

Webcam version : http://study.marearts.com/2017/10/webcam-histogram-test-opencv.html

Let's make a histogram

- Make histogram using OpenCV
  - A histogram for HSV
    - Hue and Saturation 2D histogram

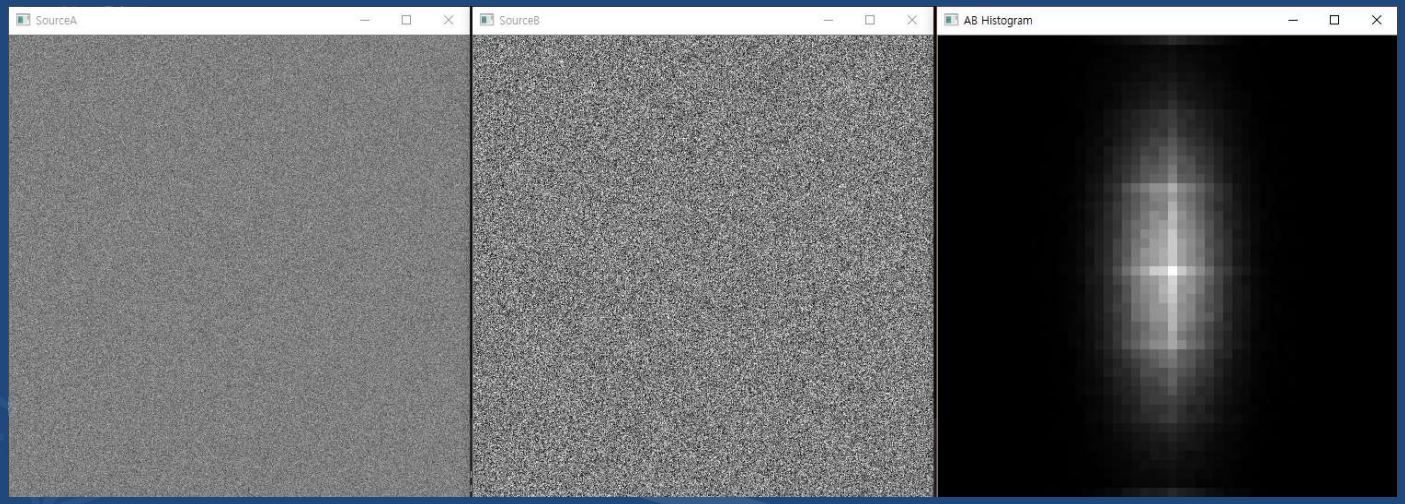



```
// Quantize the hue to 30 levels
// and the saturation to 32 levels
int hbins = 30, sbins = 32;
int histSize[] = {hbins, sbins};
// hue varies from 0 to 179, see cvtColor
float hranges[] = { 0, 180 };
// saturation varies from 0 (black-gray-white) to
// 255 (pure spectrum color)
float sranges[] = { 0, 256 };
const float* ranges[] = { hranges, sranges };
MatND hist;
// we compute the histogram from the 0-th and 1-st channels
int channels[] = {0, 1};

calcHist( &hsv, 1, channels, Mat(), // do not use mask
         hist, 2, histSize, ranges,
         true, // the histogram is uniform
         false );
double maxVal=0;
minMaxLoc(hist, 0, &maxVal, 0, 0);

int scale = 10;
Mat histImg = Mat::zeros(sbins*scale, hbins*10, CV_8UC3);

for( int h = 0; h < hbins; h++ )
    for( int s = 0; s < sbins; s++ )
    {
        float binVal = hist.at<float>(h, s);
        int intensity = cvRound(binVal*255/maxVal);
        rectangle( histImg, Point(h*scale, s*scale),
                   Point( (h+1)*scale - 1, (s+1)*scale - 1),
                   Scalar::all(intensity),
                   CV_FILLED );
    }
```

Reference source code:
https://docs.opencv.org/2.4/modules/imgproc/doc/histograms.html?highlight=calchist#histograms

Let's make a histogram

- Make histogram using OpenCV
  - A histogram for 2D




```
Mat srcA = Mat(500, 500, CV_8UC1);
randn(srcA, 128, 20); //mean, variance

Mat srcB = Mat(500, 500, CV_8UC1);
randn(srcB, 128, 50); //mean, variance

int aBin = 50, bBin = 50;
int histSize[] = { aBin, bBin };

float aranges[] = { 0, 256 };
float branges[] = { 0, 256 };
const float* ranges[] = { aranges, branges };

MatND hist;
int channels[] = { 0, 1 };

Mat mat2ch[2];
mat2ch[0] = srcA;
mat2ch[1] = srcB;

calcHist(mat2ch, 2, channels, Mat(), // do not use mask
    hist, 2, histSize, ranges,
    true, // the histogram is uniform
    false);
double maxVal = 0;
minMaxLoc(hist, 0, &maxVal, 0, 0);
```

Refer to this URL about random generating :
http://study.marearts.com/2014/11/opencv-randn-example.html
http://cvlecture.marearts.com/2017/03/opencv-lecture-4-7-noise-generation.html

Histogram Stretching

- Stretching?
  - It is just adjusting the range with same ratio
  - For example, we have a range of numbers.
    - 60, 61, 62, 63, 64, 65
  - And we want to stretch this range to 0~255 range.
    - As result these number will be matched like that
    - [60, 61, 62, 63, 64, 65] -> [0, 51, 102, 153, 204, 255]
  - How to calculate?
    - $ratio = \frac{tMax - tM}{oMax - oMin}$
    - In this case, tMax=255, tMin=0, oMax=65, oMin=60

```
o = [60, 61, 62, 63, 64, 65];
t = [0, 255];
oMin = min(o);
oMax = max(o);
tMin = min(t);
tMax = max(t);
ratio = (tMax-tMin)/(oMax-oMin);
stretch=(o-oMin)*ratio
```

```
stretch =

     0    51   102   153   204   255
```

Histogram Stretching

Stretching?

$$ratio = \frac{tMax - tMin}{oMax - oMin}$$

*Matlab code

```
o = [60, 61, 62, 63, 64, 65];
t = [0, 255];
oMin = min(o);
oMax = max(o);
tMin = min(t);
tMax = max(t);
ratio = (tMax-tMin)/(oMax-oMin);
stretch=(o-oMin)*ratio
```

```
stretch =

     0    51   102   153   204   255
```

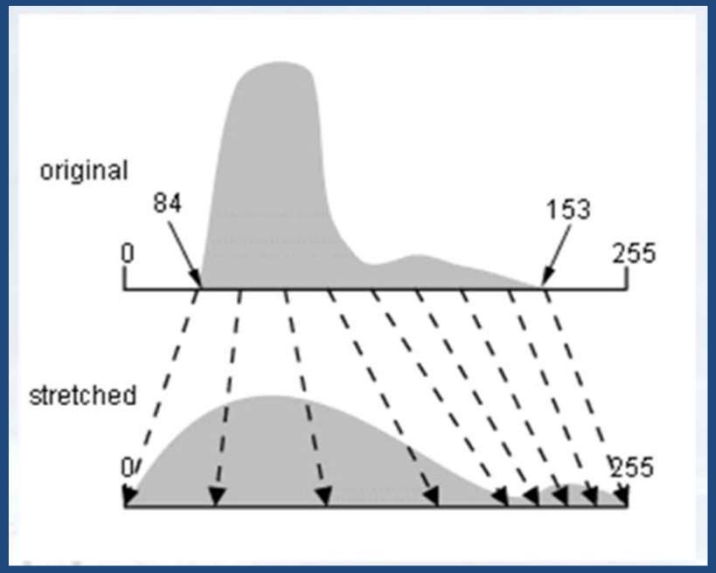
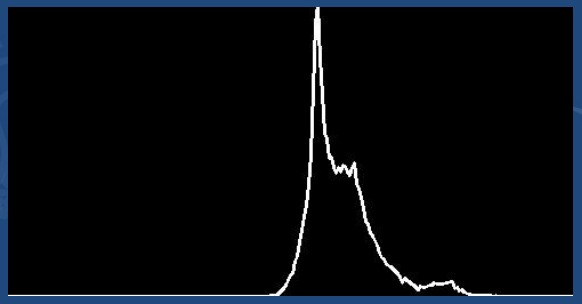


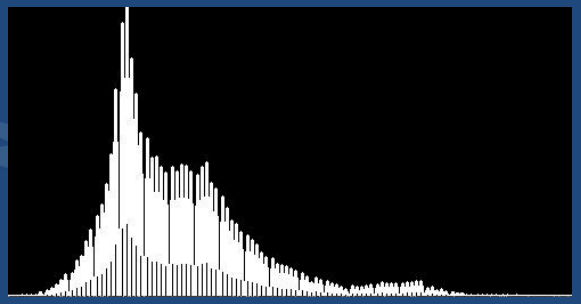
Image Source : https://stackoverflow.com/questions/41118808/difference-between-contrast-stretching-and-histogram-equalization

Histogram Stretching

- Stretching?
  - Compare the origin image and stretching image

```
//strech
Mat grayImg_stretch;
normalize(grayImg, grayImg_stretch, 0, 255, CV_MINMAX);
Mat histStretchImg = getHistoImage(grayImg_stretch);
imshow("grayImg_stretch", grayImg_stretch);
```



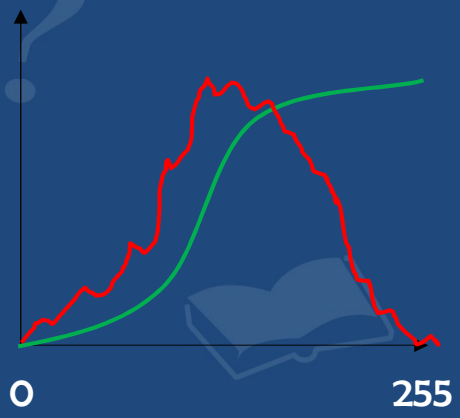


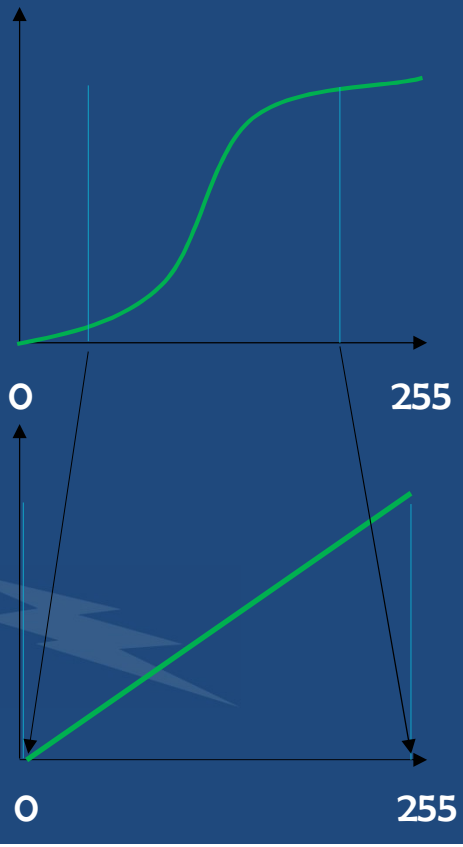
*Assignment: make stretched image
not using OpenCv function!

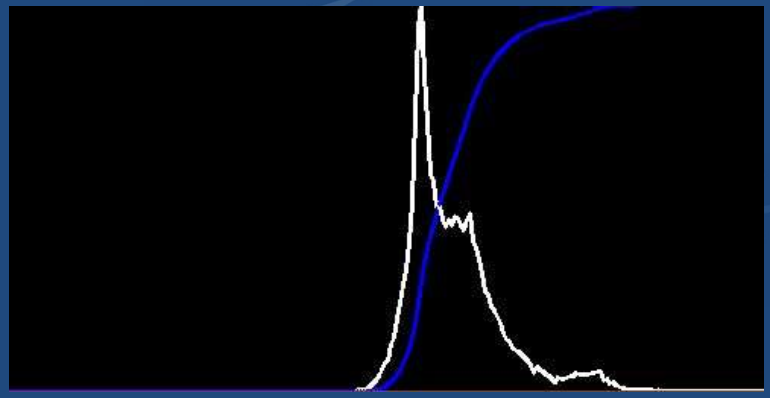
Soruce code : http://study.marearts.com/2017/12/opencv-histogram-stretching-example.html

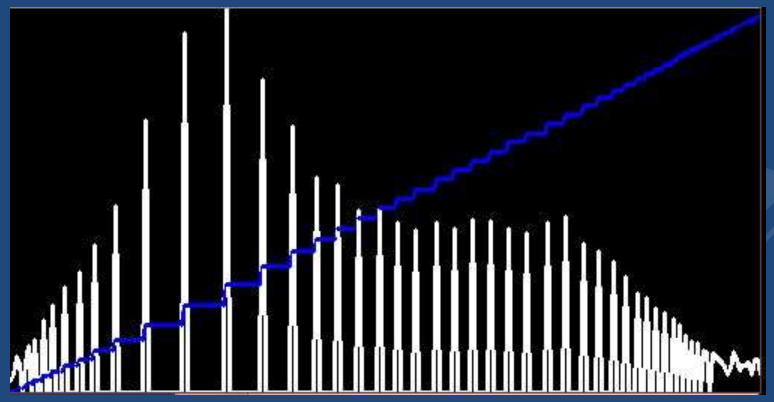
Histogram Equalization

- Equalize



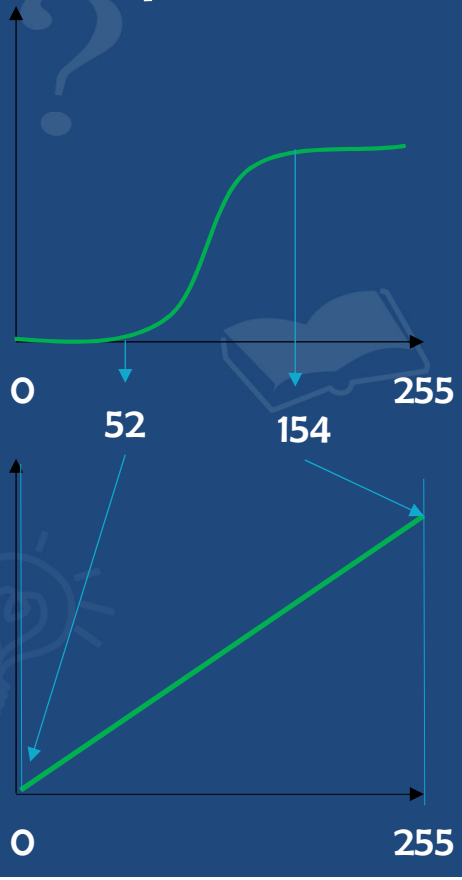






Histogram Equalization

Equalize



Pixel v	cdf	Equl.
52	1	0
…	…	…
154	64	255

$$h(v) = \text{round}\left(\frac{cdf(v) - cdf_{min}}{(M \times N) - 1} \times (L - 1)\right)$$

M is width and N the height

L is the number of grey levels used (in most cases, like this one, 256).

Ex)

$$h(78) = \text{round}\left(\frac{46 - 1}{63} \times 255\right) = \text{round}\left(0.714286 \times 255\right) = 182$$

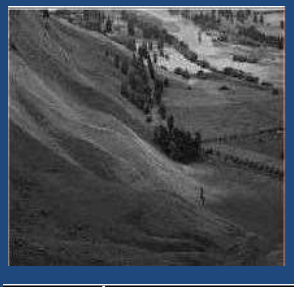
H(78) : input pixel value -> 78
46: cdf value of 78 pixel
1 : minimum value in cdf values
63 : width x height

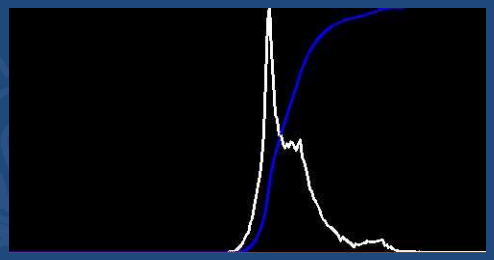
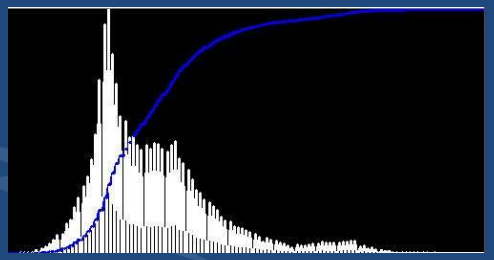
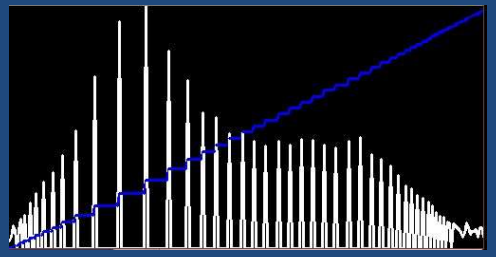
Reference : https://en.wikipedia.org/wiki/Histogram_equalization

Histogram Equalization

Equalize

```
Mat grayImg_equalization;
equalizeHist(grayImg, grayImg_equalization);
```

origin

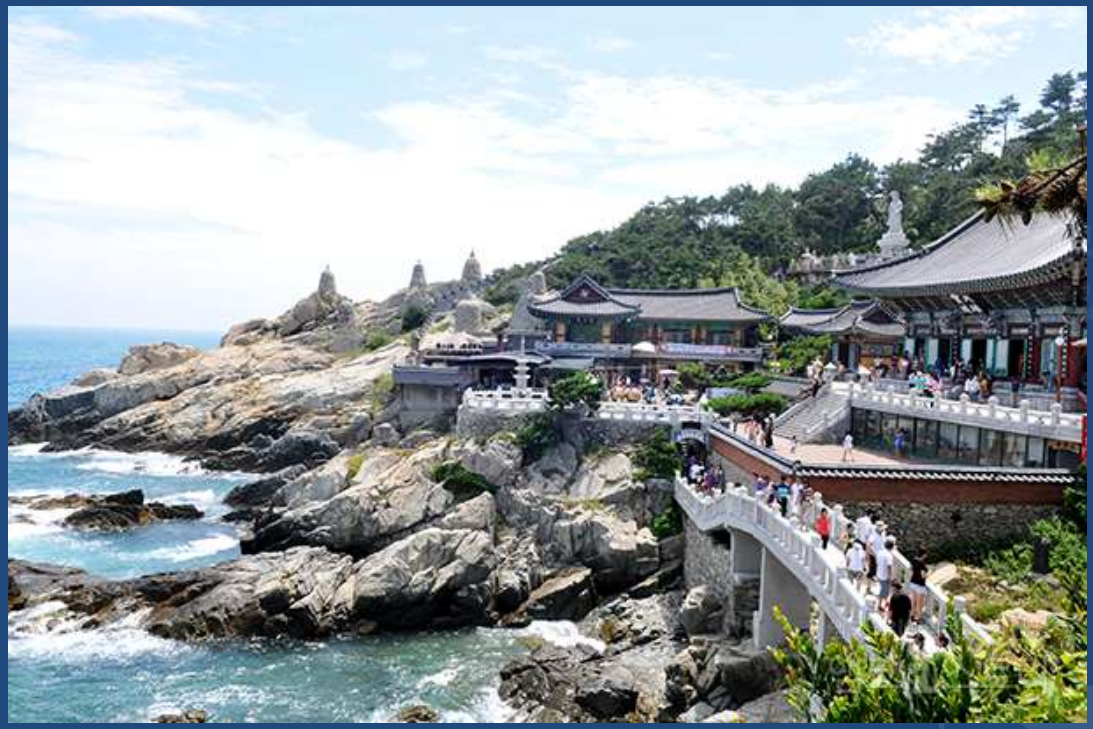
stretching

equalization

Source code : http://study.marearts.com/2018/01/histogram-equalization-stretching.html

Thank you.

- See you later ~



Haedong Yonggung Temple at busan gijang