Embedded Vision Design

EVD1 - Week 1

Image Fundamentals
Histogram Operations

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Image Fundamentals

- Functions for creating and deleting images
- Functions for converting images
- Functions for reading and writing pixels
- Basic image processing operators

- Scaling

Scaling

- Used to enhance contrast
- Used to scale larger pixel datatypes to smaller pixel datatypes e.g. float_pixel_t to uint8_pixel_t
- Min-max scaling is defined as

$$p_{dst}(x,y) = \frac{dst_{max} - dst_{min}}{src_{max} - src_{min}} \cdot (p_{src}(x,y) - src_{min}) + dst_{min}$$

where

src_{min}: $global\ minimum\ of\ the\ source\ image$
src_{max}: $global\ maximum\ of\ the\ source\ image$
dst_{min}: $global\ minimum\ of\ the\ destination\ image$
dst_{max}: $global\ maximum\ of\ the\ destination\ image$

Scaling

- Used to enhance contrast
- Used to scale larger pixel datatypes to smaller pixel datatypes e.g. float_pixel_t to uint8_pixel_t
- Min-max scaling is defined as

$$p_{dst}(x,y) = \underbrace{\frac{dst_{max} - dst_{min}}{src_{max} - src_{min}}}_{\text{Scale factor (fraction)}} \cdot (p_{src}(x,y) - src_{min}) + dst_{min}$$

$$= \frac{new\ range}{old\ range}$$

Scaling

- Used to enhance contrast
- Used to scale larger pixel datatypes to smaller pixel datatypes e.g. float_pixel_t to uint8_pixel_t
- Min-max scaling is defined as

$$p_{dst}(x,y) = \frac{dst_{max} - dst_{min}}{src_{max} - src_{min}} \cdot \underbrace{(p_{src}(x,y) - src_{min})}_{\text{Scale with respect to the lowest pixel value in the source image}} + dst_{min}$$

Scaling

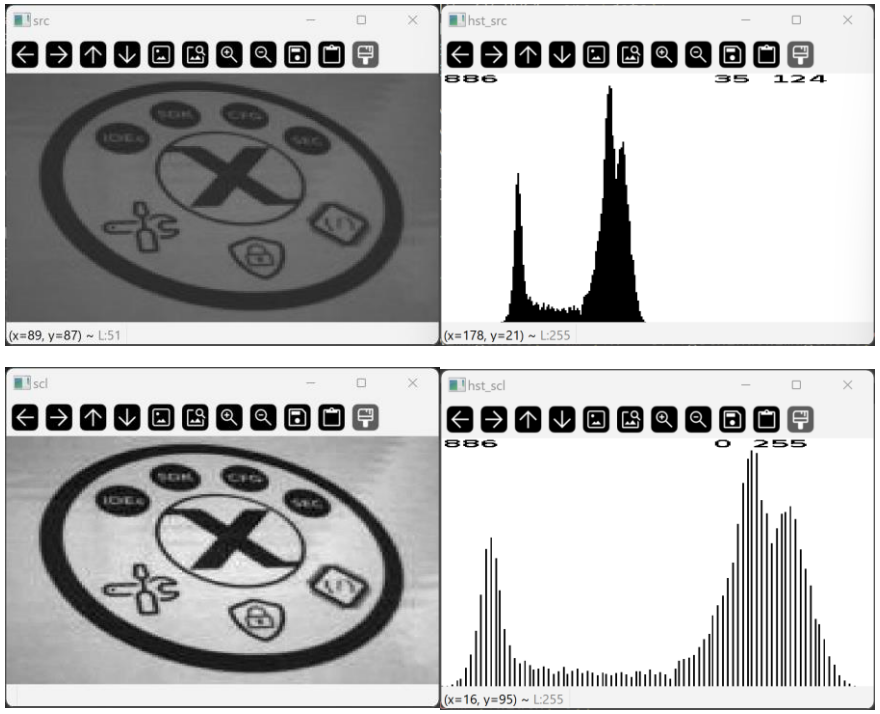
- Used to enhance contrast
- Used to scale larger pixel datatypes to smaller pixel datatypes e.g. float_pixel_t to uint8_pixel_t
- Min-max scaling is defined as

$$p_{dst}(x,y) = \frac{dst_{max} - dst_{min}}{src_{max} - src_{min}} \cdot (p_{src}(x,y) - src_{min}) + dst_{min}$$

Move scaled values to new minimum value

Scaling - example

$$p_{dst}(x,y) = \frac{255-0}{src_{max}-src_{min}} \cdot (p_{src}(x,y) - src_{min}) + 0$$



Scaling - algorithm

void **scale**(const image_t ***src**, image_t ***dst**);

See file **evdk_operators\image_fundamentals.c**

Histogram Operations

- Are operations that do not require spatial information
- Treat the graylevels as a set of numbers represented by a histogram
- Modifying the graylevel histogram improves visual appearance

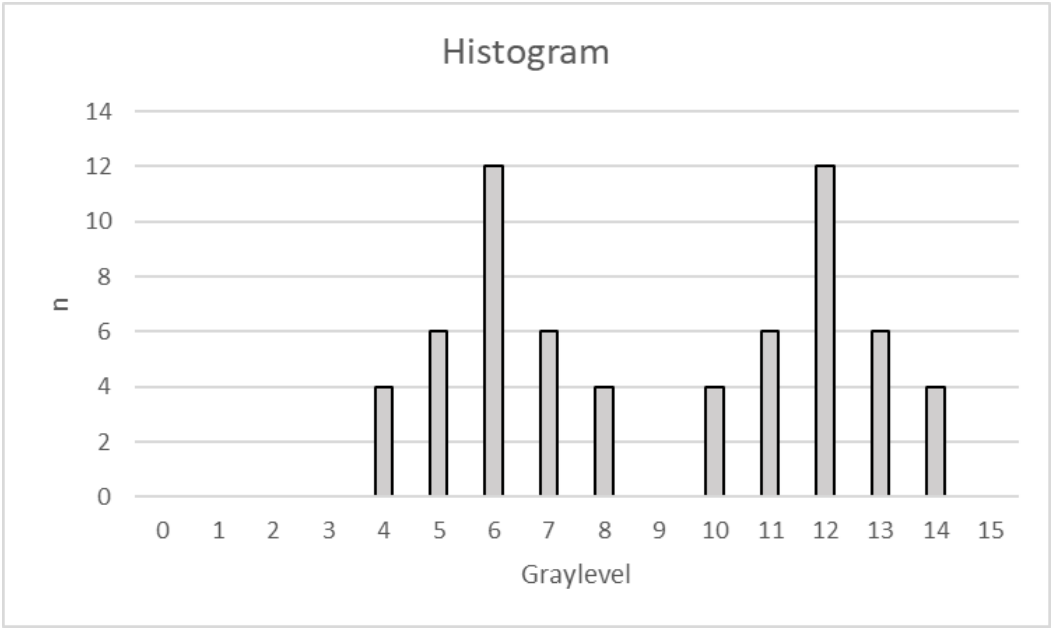
- Histogram
- Brightness correction
- Contrast correction

Histogram

- Shows for each graylevel the number of pixels in the image

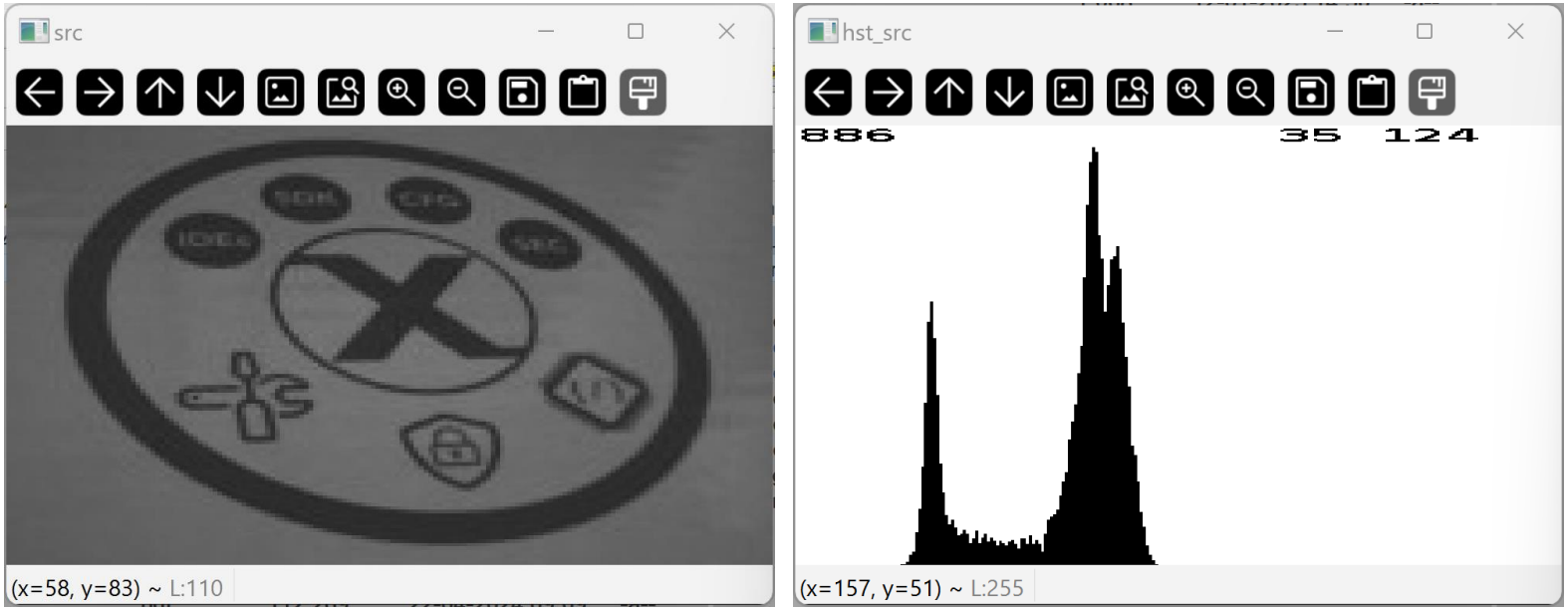
image

4	4	4	4	5	5	5	5
5	5	6	6	6	6	6	6
6	6	6	6	6	6	7	7
7	7	7	7	8	8	8	8
10	10	10	10	11	11	11	11
11	11	12	12	12	12	12	12
12	12	12	12	12	12	13	13
13	13	13	13	14	14	14	14



Histogram - example

See Qt example evdk5_histogram_webcam



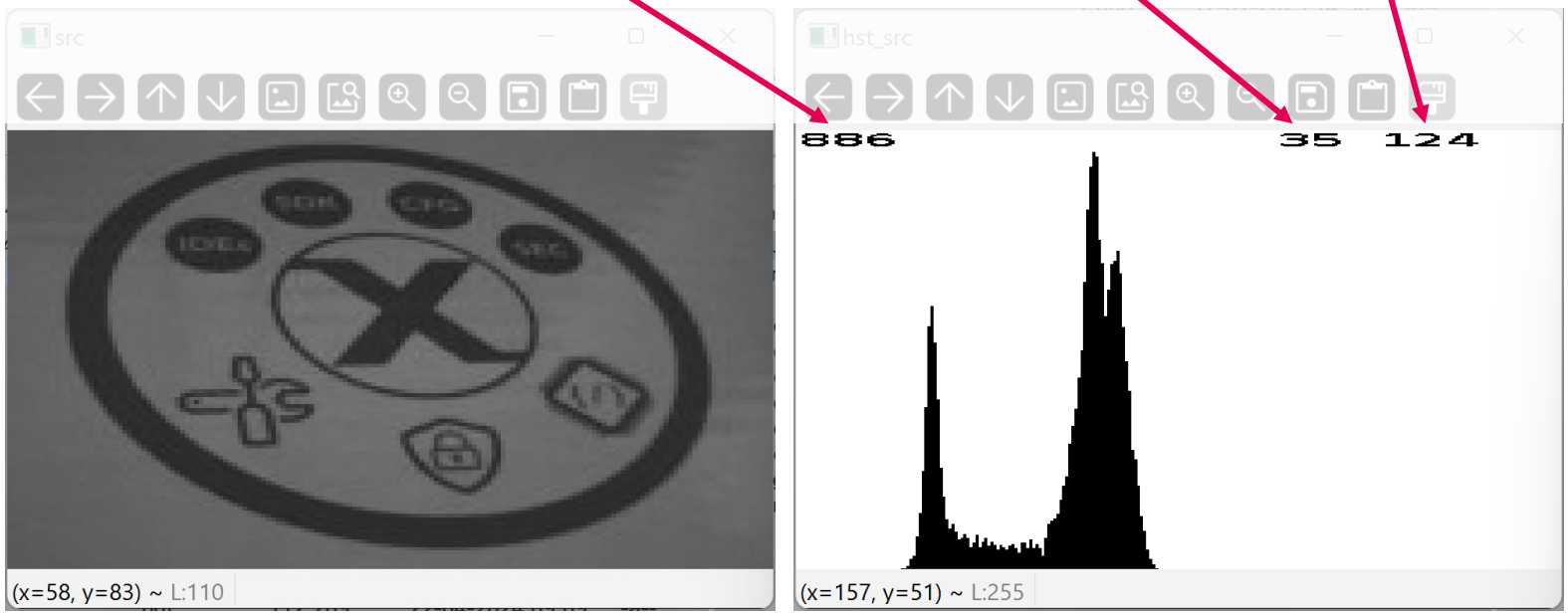
Histogram - example

See Qt example evdk5_histogram_webcam

Max number of pixels for single graylevel

min graylevel

max graylevel



Histogram - algorithm

void **histogram**(const image_t ***img**, uint32_t ***hist**);

See file **EVDK_Operators\histogram_operations.c**

The function does not check memory boundaries. It simply assumes that the hist pointer points to memory allocated by the caller of this function. The size of the histogram must be 256 times a uint32_t.

Brightness correction

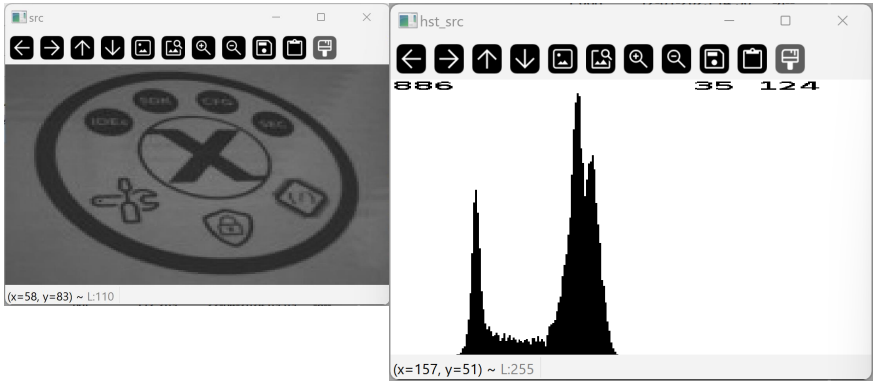
- Enhances the visual appearance of an image
- Brightness modification is defined as

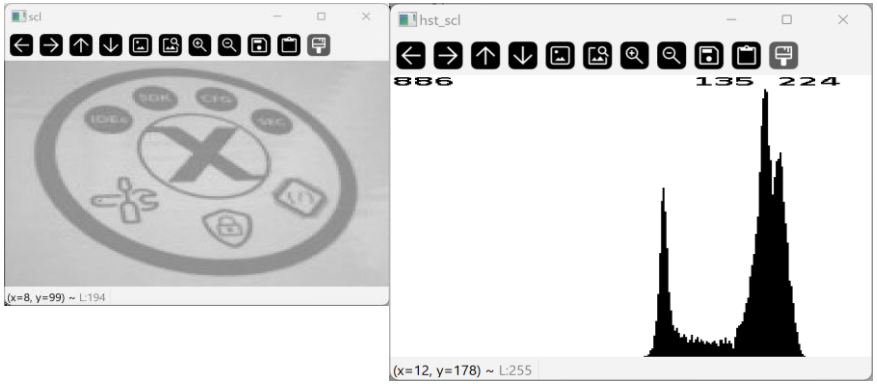
$$s_{(x,y)} = g_{(x,y)} + brightness$$

where
$s_{(x,y)}$: $graylevel\ of\ the\ enhanced\ pixel\ at\ (x,y)$
$g_{(x,y)}$: $graylevel\ of\ the\ original\ pixel\ at\ (x,y)$

Brightness correction - example

$$brightness = 100$$





Brightness correction - example

$$brightness = 200$$

Brightness correction - algorithm

void **brightness**(const image_t ***src**, image_t ***dst**,
const uint32_t **brightness**);

See file **EVDK_Operators\histogram_operations.c**

Contrast correction

- Enhances the visual appearance of an image
- Contrast correction is defined as

$$s_{(x,y)} = contrast \cdot (g_{(x,y)} - average) + average$$

where
$s_{(x,y)}$: $graylevel\ of\ the\ enhanced\ pixel\ at\ (x,y)$
$g_{(x,y)}$: $graylevel\ of\ the\ original\ pixel\ at\ (x,y)$
$average$: $mean\ pixel\ value\ of\ the\ original\ image\ given\ by$

$$average = \frac{1}{n_x n_y} \sum_{x=0}^{n_x} \sum_{y=0}^{n_y} p(x,y)$$

where
n_x: $number\ of\ columns\ of\ the\ image$
n_y: $number\ of\ rows\ of\ the\ image$
$p(x,y)$: $graylevel\ of\ the\ original\ pixel\ at\ (x,y)$

Contrast correction

- Calculating the average

$$average = \frac{1}{n_x n_y} \underbrace{\sum_{x=0}^{n_x} \sum_{y=0}^{n_y} p(x,y)}$$

The sum of all pixel values, can be calculated in a double for-loop

Contrast correction

- Calculating the average

$$average = \underbrace{\frac{1}{n_x n_y}} \sum_{x=0}^{n_x} \sum_{y=0}^{n_y} p(x, y)$$

Divided by the number of pixels: $rows \times cols$

Contrast correction

- Calculate the contrast modification

$$s_{(x,y)} = contrast \cdot \underbrace{(g_{(x,y)} - average)}_{\text{Distance to the average pixel value (positive, zero, or negative)}} + average$$

Contrast correction

- Calculate the contrast modification

$$s_{(x,y)} = \underbrace{contrast \cdot}_{\text{Change the distance to the average pixel value}} (g_{(x,y)} - average) + average$$

Contrast correction

- Calculate the contrast modification

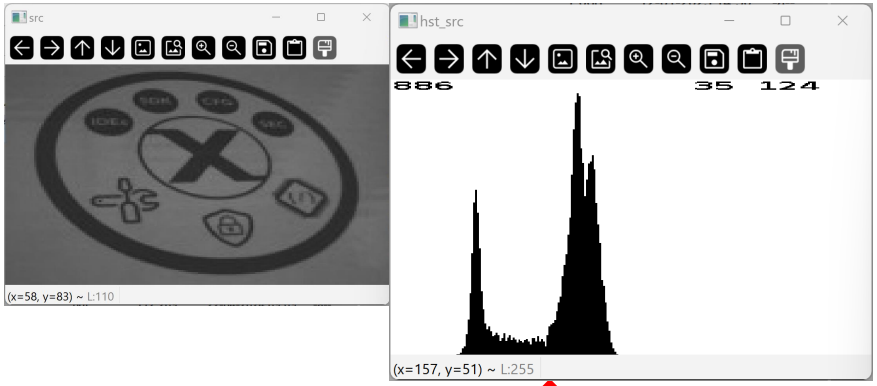
$$s_{(x,y)} = contrast \cdot (g_{(x,y)} - average) + average$$

Move back to original average pixel value

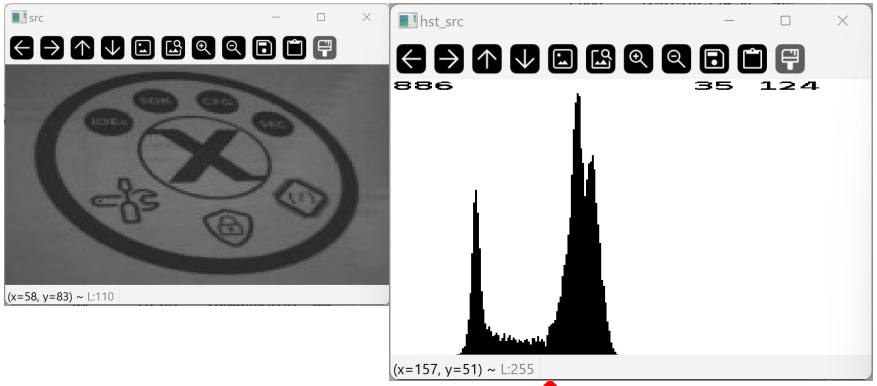
Contrast correction - example

$$contrast = 1$$

Contrast is equal



$average$

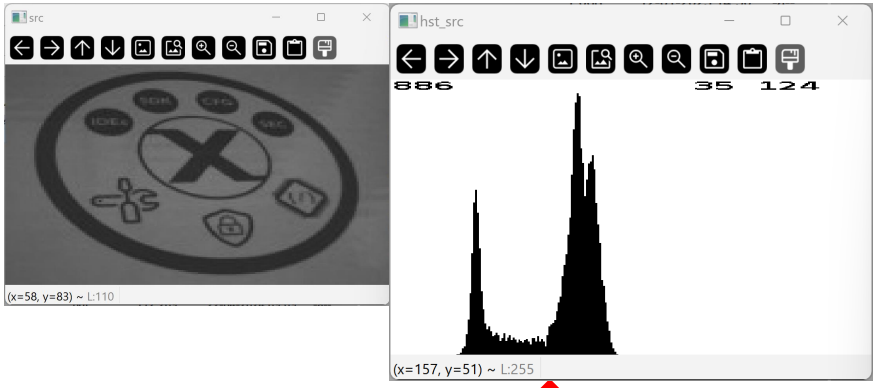


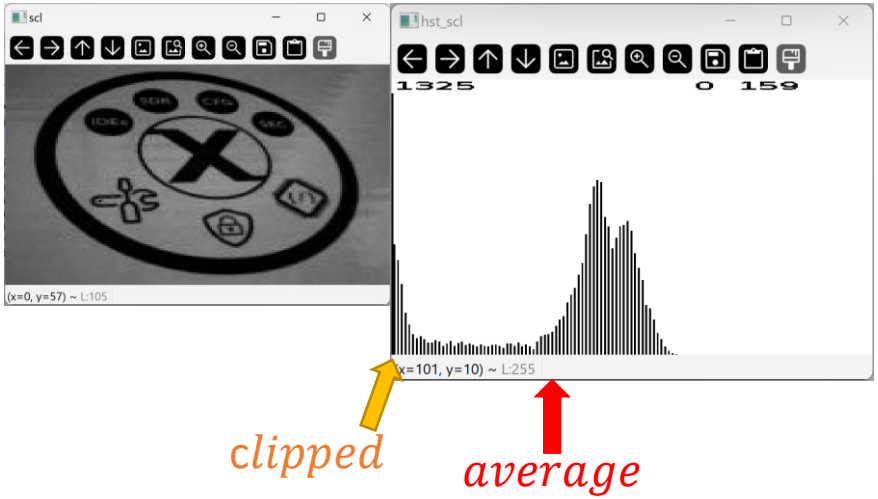
$average$

Contrast correction - example

$$contrast = 2$$

The histogram shows twice the contrast, however, **the results are clipped**

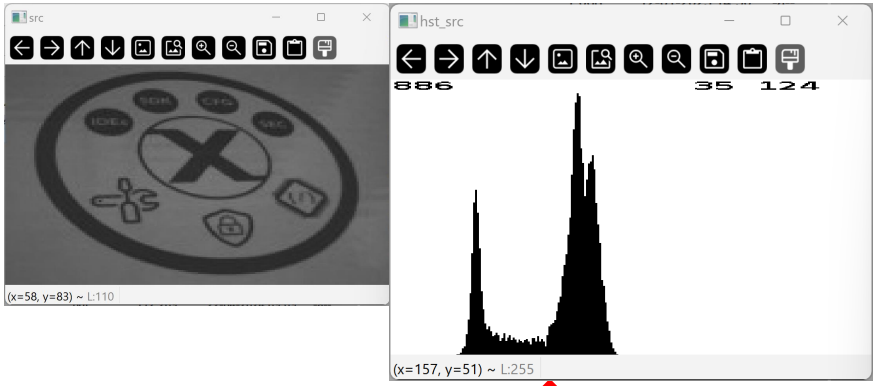




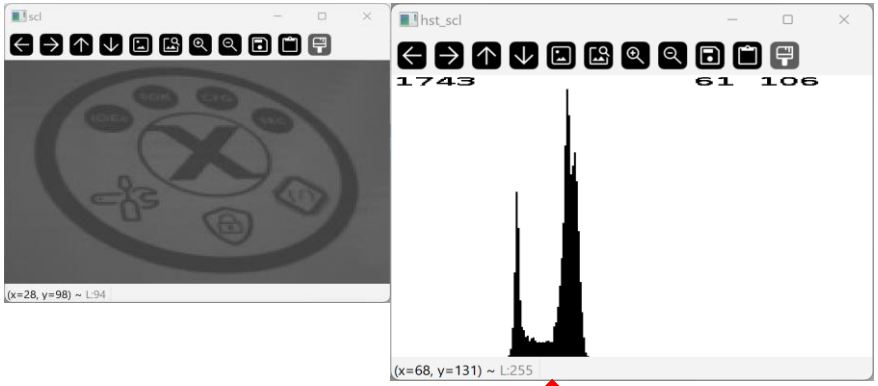
Contrast correction - example

$$contrast = 0.5$$

The histogram shows half the contrast



average

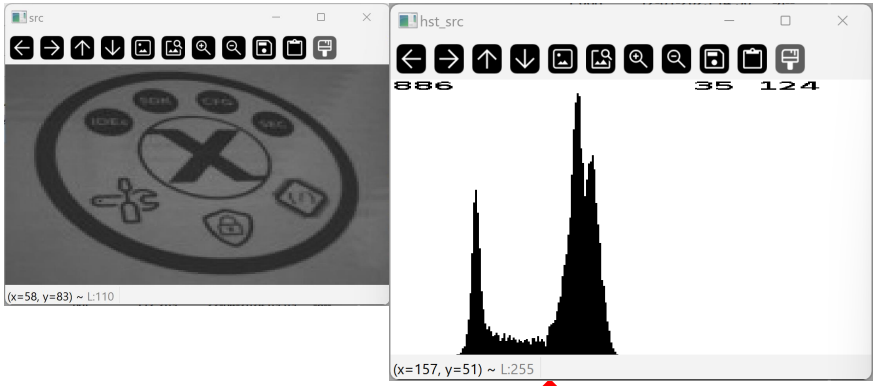


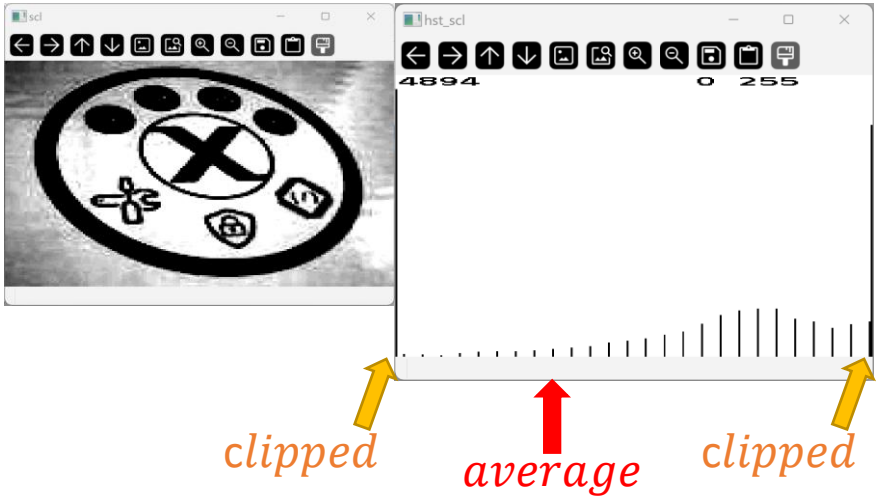
average

Contrast correction - example

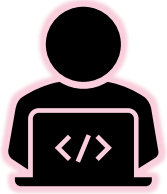
$$contrast = 10$$

The histogram shows ten times the contrast, **clipping the result**





EVD1 – Assignment



Study guide

Week 1

8 Histogram operations – contrast()

References

- Myler, H. R., & Weeks, A. R. (2009). *The pocket handbook of image processing algorithms in C*. Prentice Hall Press.