**CS 6643 - Computer Vision, Spring 2019** **Guido Gerig**

**Assignment 2**

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**Out:** Wed 02 / 27 / 2019
**Due:** Mon 03 / 11 / 2019 (deadline: midnight)

**Late submissions:** Late submissions result in 10% deduction for each day. The assignment will no longer be accepted 3 days after the deadline.

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**Office hours:**

| | | Mon | Tue | Wed | Thu |
|---|---|---|---|---|---|
| **Guido Gerig** | Office 10.094 | | | | |
| **Andrew Dempsey** | ad4338@nyu.edu | 10-12am | | | |
| **Anshul Sharma** | as10950@nyu.edu | | 10-12am | | |
| **Bhavana Ramakrishna** | br1525@nyu.edu | | | 10-12am | |

**Location:** cubicle spaces in 2 Metrotech, 10.098 A, B, D, E, H

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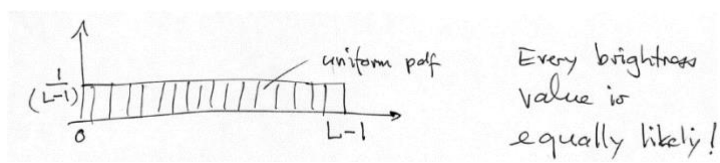
## A) Histogram Equalization

**A1)** It is the main goal of Histogram Equalization to equally distribute frequencies of intensity occurrence so that the result is a uniform distribution (see figure). Practically, you get the result as shown on a real image. Can you explain why the result is not a uniform distribution as you may have expected?



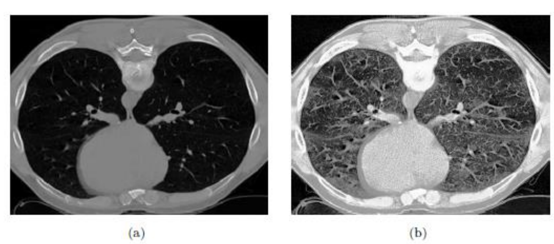




**Figure 5.3:** Histogram equalization. (a) Original image. (b) Equalized image. © *Cengage Learning 2015.*

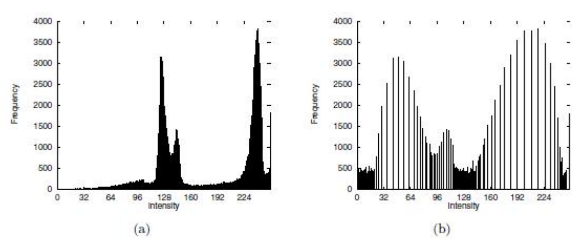



**Figure 5.4:** Histogram equalization: Original and equalized histograms corresponding to Figure 5.3a,b. © *Cengage Learning 2015.*

**A2)** What happens if you equalize the histogram of an image and then repeat the procedure a second time, meaning you apply the procedure to the equalized image? What do you predict to happen to the new histogram?

**A3**) Does histogram equalization increase the amount of information contained in image data? Explain.

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## B) Filtering

### B1) Filter kernels

As discussed, image filter weights are normalized to 1. Discuss why we introduce such a normalization.

**B2) Separability of filter kernels**: The course discussed that some filters can be separated into an x- and y-component. Let us use the example of a box filter of size 5x5.

$$1/25 * \begin{matrix} 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \end{matrix}$$

a) Show numerically that the box filter can be decomposed into 1D column and row filters.
b) You convolve an image with the 2D filter 5x5 kernel. Calculate the number of operations per pixel in regard to multiplications and additions per input pixel.
c) You now separate the filter into an x- and a y-component and filter your image. Again, calculate the number of operations per pixel in regard to multiplications and additions.
d) Compare the results of b) versus c), what do you see?

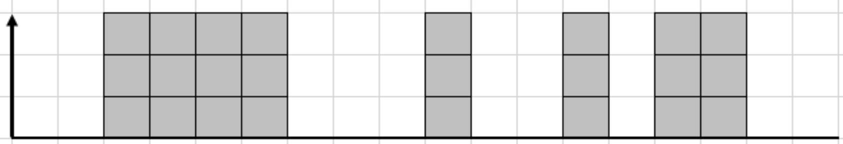
### B3) Image Preprocessing

Filter

| | | | |
|---|---|---|---|
| 1/3 | 1 | 1 | 1 |

Image Signal

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 3 | 3 | 3 | 3 | 0 | 0 | 0 | 3 | 0 | 0 | 3 | 0 | 3 | 0 | 0 | 0 |



**a)** Convolve the 1D image signal with the linear filter with the three elements. Graph the result as a row of numbers and a 1-D plot as also shown above.
**b)** Now apply a median filter with 3 elements and graph the result.
**c)** Discuss what you see and compare a) versus b).

## C) Edge Detection

In the course, we discussed methods to detect intensity discontinuities, called edges, via applying filters and postprocessing.

$$M_x = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix} \qquad M_y = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix}$$

| | | |
|---|---|---|
| 0 | –1 | 0 |
| –1 | 4 | –1 |
| 0 | –1 | 0 |

**a)** Look at the three masks above and describe its effect on an image after filtering.

**b)** The course discussed edge detection via using filters that represent derivatives. Explain for the pair Mx and My, how would filtering and additional processing result in an edge map. Explain for the third filter mask, how to filter and then obtain image edges.