Exercise Session 3

Document Image Analysis

Rolf Ingold, Anna Scius-Bertrand, Najoua Rahal
DIVA Group, University of Fribourg, Switzerland

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Reminder: assignment 1

- Tonight: assignment 1
- Next week: assignment 2
  - Deadline: October 11th, end of the day
- Submit your solution via ILIAS in one folder:
  - Results images
  - A text file with your name, surname, GitHub link and a brief description of your algorithm.

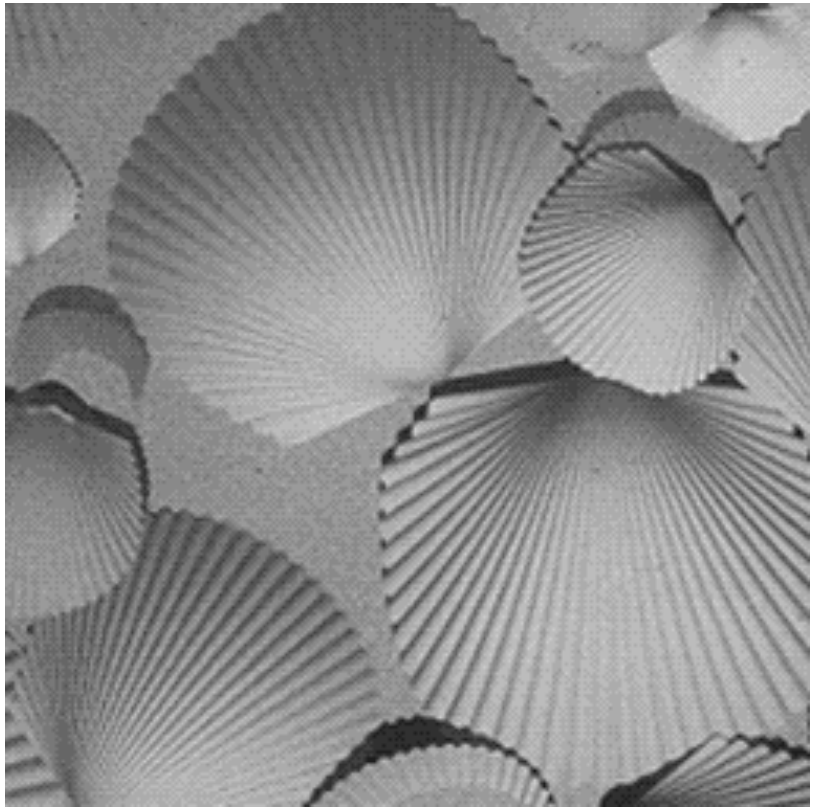
Reminder : Assignment 2: Indexed colours

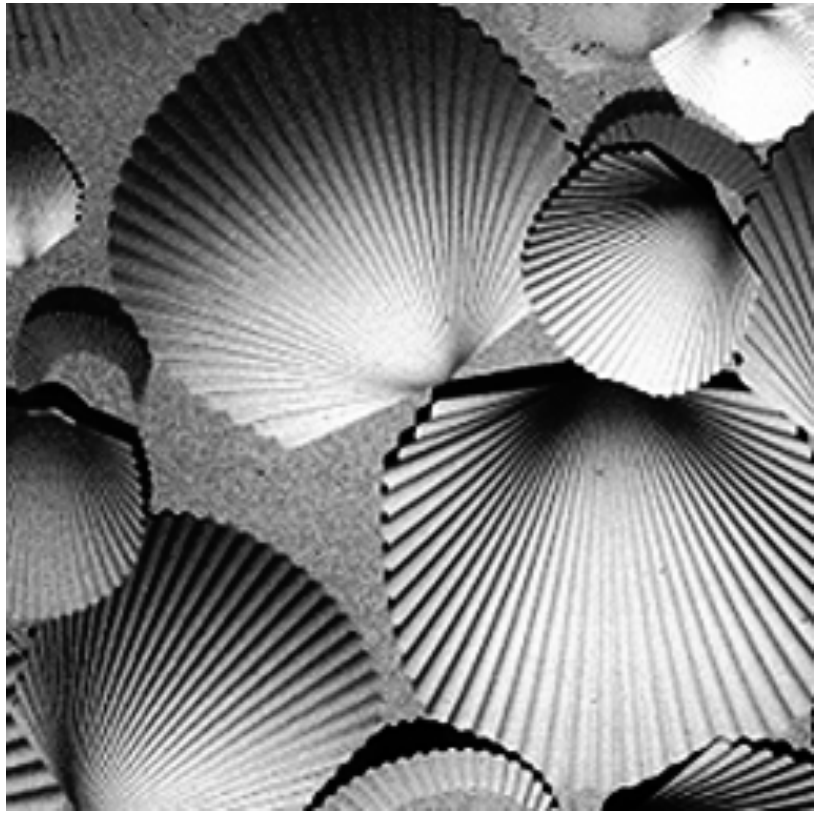
- Goal: represent a RGB image with indexed color using a limited number of colors.

- Define a universal color table with a maximum of 256 different colors.
- transforms the initial pixel values with an index to the color table so that the return image looks as similar as possible to the original image.
- Bonus: replace the universal color table by an adaptive color table, which is optimized for the given input image.
- In both case, provide the color table.

Assignment 3: Histogram Equalization

- Goal: write and apply histogram equalization on greyscale images and color images.
- Compare the histogram equalization applied to different color representations.
- Color conversions will be needed: to implemented by yourself





1. Colors separation and reconstruction

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a) Use an existing library to separate the three channels of your RGB image and show each of them separately.

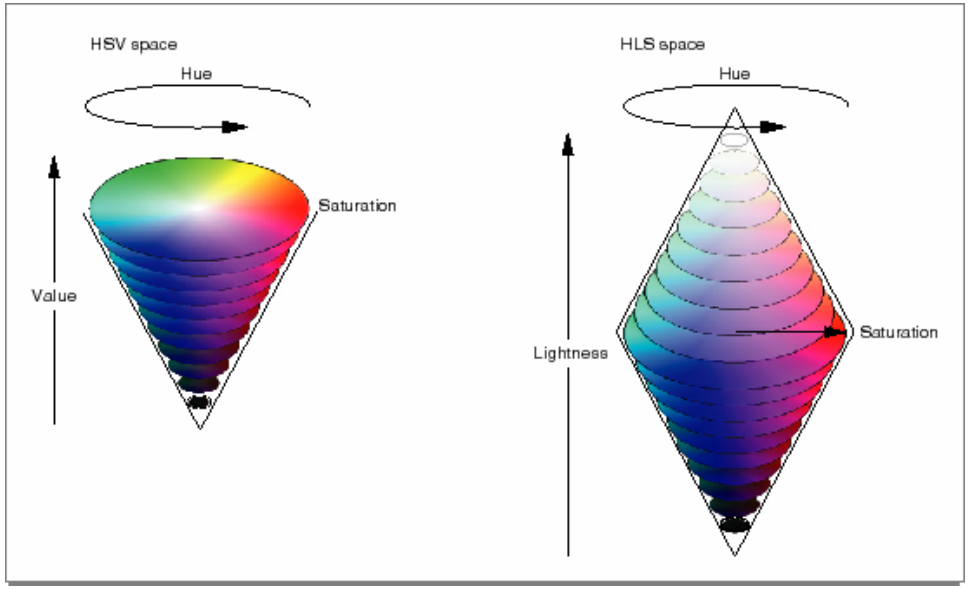
b) Write your own algorithm to separate an RGB image into the three channels of the HSL color space (H, S, L). See https://www.rapidtables.com/convert/color/ rgb-to-hsl.html

c) Write your own algorithm to reconstruct an RGB image from the H, S, L channels. See https://www.rapidtables.com/convert/color/hsl-to-rgb.html

Red

Green

Blue



Conversion formula

RGB to HSL conversion formula

The *R*,*G*,*B* values are divided by 255 to change the range from 0..255 to 0..1:

$$R' = R/255$$

$$G' = G/255$$

$$B' = B/255$$

$$Cmax = \max(R', G', B')$$

$$Cmin = \min(R', G', B')$$

$$\Delta = Cmax - Cmin$$

Hue calculation:

$$H = \begin{cases} 0^\circ & \Delta = 0 \\ 60^\circ \times \left(\frac{G'-B'}{\Delta} mod 6\right) & , C_{max} = R' \\ 60^\circ \times \left(\frac{B'-R'}{\Delta} + 2\right) & , C_{max} = G' \\ 60^\circ \times \left(\frac{R'-G'}{\Delta} + 4\right) & , C_{max} = B' \end{cases}$$

Saturation calculation:

$$S = \begin{cases} 0 & , \Delta = 0 \\ \frac{\Delta}{1-\lvert 2L-1 \rvert} & , \Delta <> 0 \end{cases}$$

Lightness calculation:

$$L = (Cmax + Cmin) / 2$$

HSL to RGB conversion formula

When $0 \le H < 360$, $0 \le S \le 1$ and $0 \le L \le 1$:

$$C = (1 - |2L - 1|) \times S$$

$$X = C \times (1 - |(H / 60^\circ) \bmod 2 - 1|)$$

$$m = L - C/2$$

$$(R', G', B') = \begin{cases} (C, X, 0) & , 0^\circ \le H < 60^\circ \\ (X, C, 0) & , 60^\circ \le H < 120^\circ \\ (0, C, X) & , 120^\circ \le H < 180^\circ \\ (0, X, C) & , 180^\circ \le H < 240^\circ \\ (X, 0, C) & , 240^\circ \le H < 300^\circ \\ (C, 0, X) & , 300^\circ \le H < 360^\circ \end{cases}$$

$$(R,G,B) = ((R'+m)\times 255, (G'+m)\times 255, (B'+m)\times 255)$$

2. Greyscale Histogram Equalization

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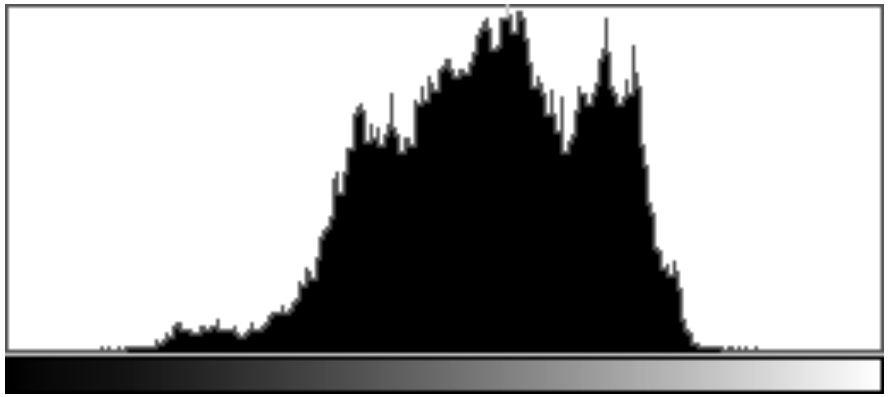
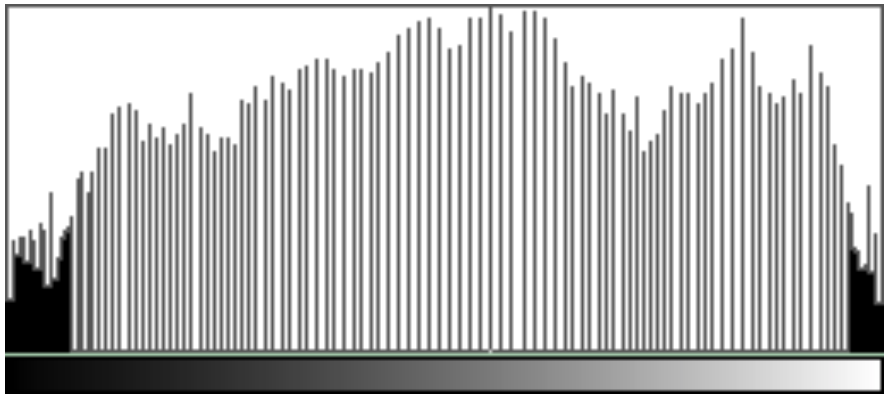
(a) Write your **own histogram equalization algorithm** based on the method presented in the lecture.

(b) **Apply** your algorithm on the **greyscale images** provided on ILIAS.

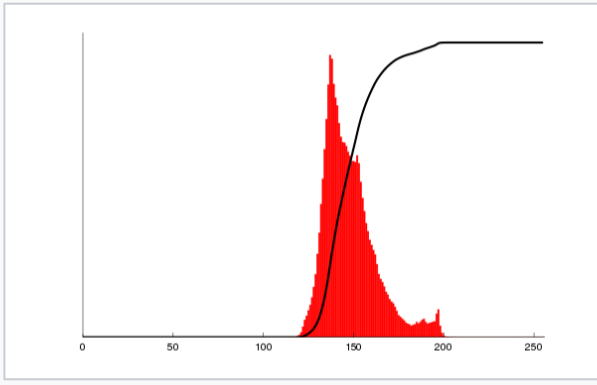




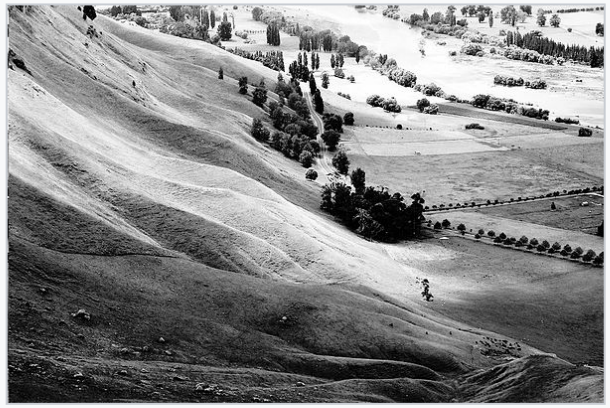
Histogram equalization

v, Pixel Intensity	cdf(v)	h(v), Equalized v
52	1	0
55	4	12
58	6	20
59	9	32
60	10	36
61	14	53
62	15	57
63	17	65
64	19	73
65	22	85
66	24	93
67	25	97
68	30	117
69	33	130
70	37	146
71	39	154
72	40	158
73	42	166

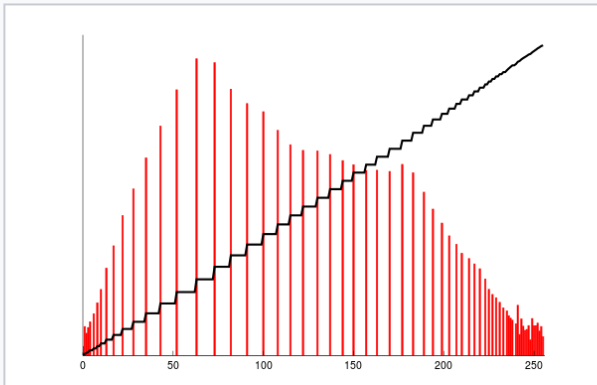
Before Histogram Equalization



Corresponding histogram (red) and cumulative histogram (black)



After Histogram Equalization



Corresponding histogram (red) and cumulative histogram (black)

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

3. Color Histogram Equalization

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(a) Firstly, **apply** your histogram equalization algorithm **on the R, G, and B channels** and **reconstruct** your image.

(b) Secondly, **apply** the histogram equalization on **the L channel of your HSL** image and **reconstruct** your image with the new L channel and the original H and S channels. **Convert** the result on an **RGB image**.

(c) Visually compare the result of the two images after equalizing the histograms (RGB and HSL). **What can you observe?**

Hand-in

- The third assignment is due in two weeks:
  - Deadline: **Tuesday, October 18, 2022** (end of day)

- Submit on ILIAS one and only one folder containing:
  - A greyscale image after applying your histogram equalization algorithm.
  - An RGB and a HSL image after applying your histogram equalization algorithm.
  - A text file with your name, surname, the link to your GitHub and a brief de- scription of your algorithms (HSL to RGB and RGB to HSL conversion, histogram equalization) and the response to the question 3. c).

Questions?