ISEL
INSTITUTO SUPERIOR
DE ENGENHARIA DE LISBOA

PROCESSAMENTO DE IMAGEM E BIOMETRIA

IMAGE PROCESSING AND BIOMETRICS

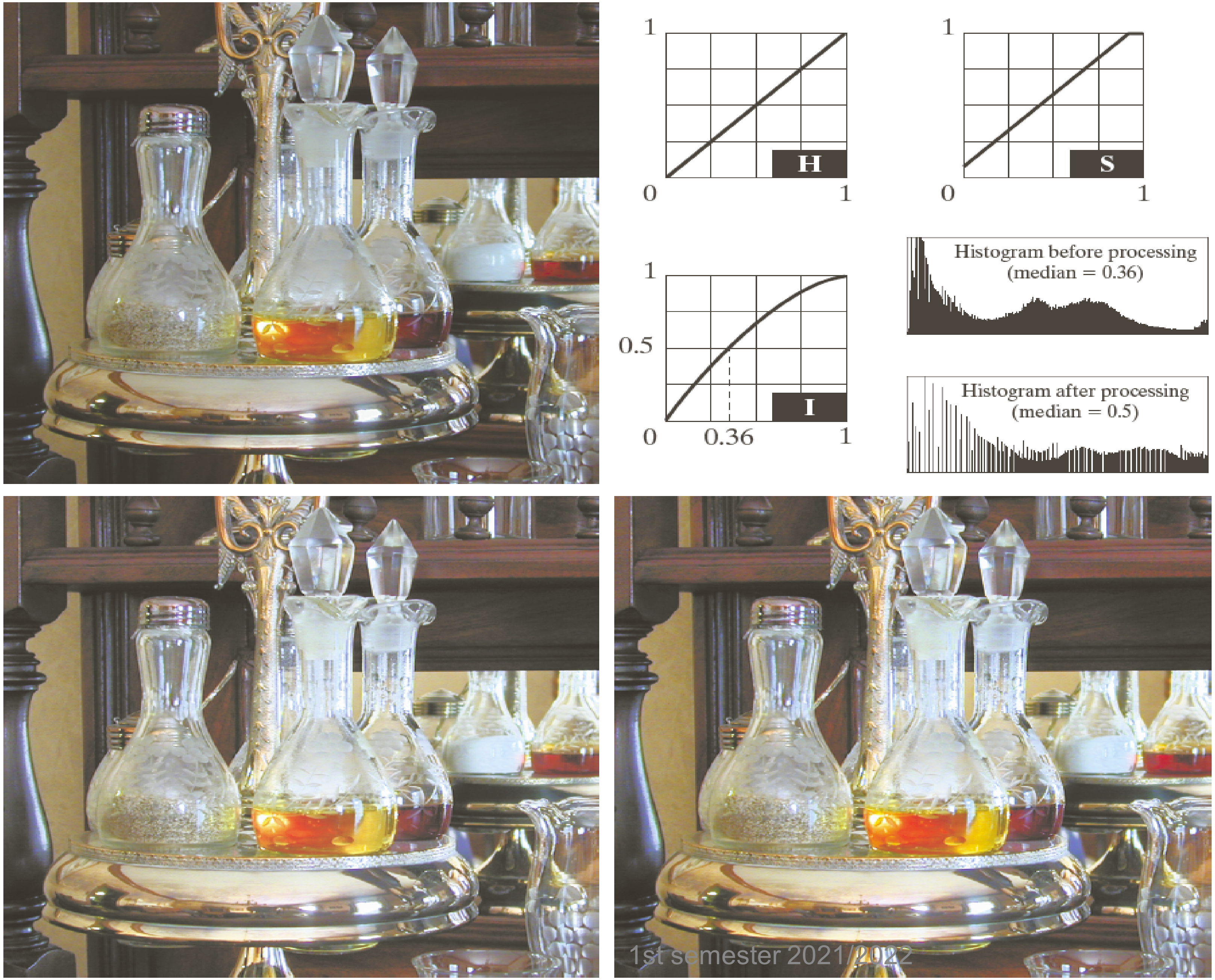
7. **COLOR IMAGE PROCESSING (part 3)**

Summary (part 3)

- Some full-color image processing operations:

  - Histogram equalization
  - Smoothing
  - Sharpening
  - Gradient
  - Segmentation
  - Exercises

Histogram Equalization



a b
c d

FIGURE 6.37 Histogram equalization (followed by saturation adjustment) in the HSI color space.

a	b
c	d

FIGURE 6.38
(a) RGB image.
(b) Red component image.
(c) Green component. (d) Blue component.

RGB and HSI representations

a b c

FIGURE 6.39 HSI components of the RGB color image in Fig. 6.38(a). (a) Hue. (b) Saturation. (c) Intensity.

Smoothing

a b c

FIGURE 6.40 Image smoothing with a 5×5 averaging mask. (a) Result of processing each RGB component image. (b) Result of processing the intensity component of the HSI image and converting to RGB. (c) Difference between the two results.

Sharpening

FIGURE 6.41 Image sharpening with the Laplacian. (a) Result of processing each RGB channel. (b) Result of processing the HSI intensity component and converting to RGB. (c) Difference between the two results.

Segmentation: some concepts

- The segmentation operation identifies image regions with some common properties (e.g. the same color or the same gray level)

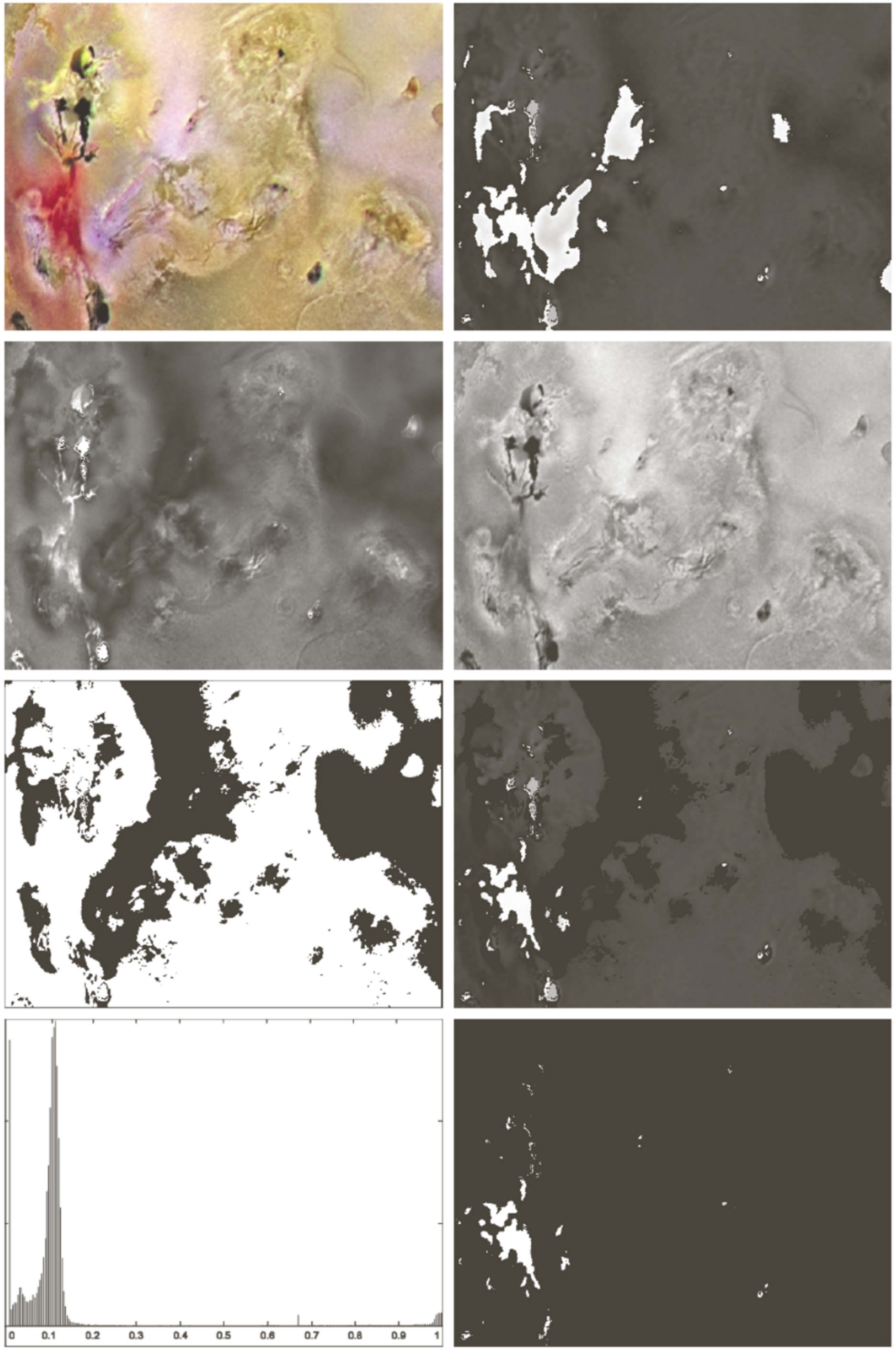
- Each pixel is marked/classified as satisfying or not that property

- The output of the segmentation method is a **binary image** which classifies each pixel of the input image as having or not that property

For instance, to check if the image pixels have (roughly) the same color, we **need a color distance measure such that**:

  - On the RGB color space, we need to check the three components

  - On the HSI color space, we only need to check the H or the (H,S) components



Segmentation on HSI color space

(a) RGB image

(b) H component

(c) S component

(d) I component

(e) Binary image mask obtained by thresholding S, with threshold T=0,1*max(S)

(f) = (b) x (e) = H x mask

(g) Histogram of (f)

(h) Thresholding of (f). Binary image with the segmentation result

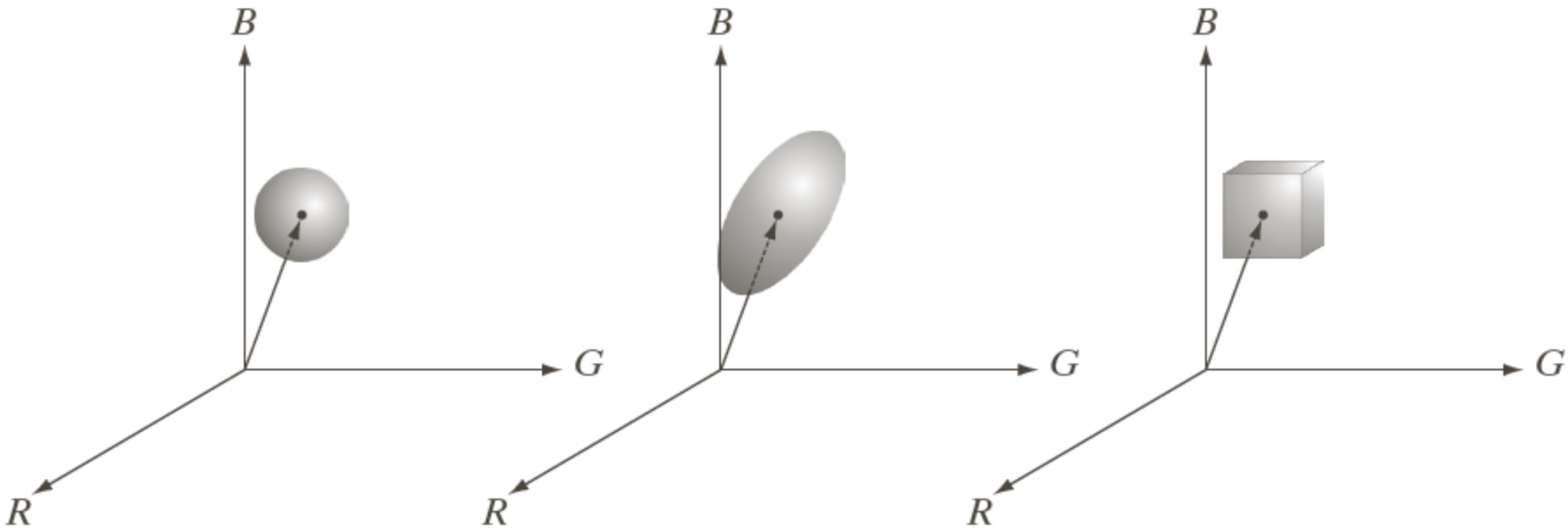
a	b
c	d
e	f
g	h

FIGURE 6.42 Image segmentation in HSI space. (a) Original. (b) Hue. (c) Saturation. (d) Intensity. (e) Binary saturation mask (black = 0). (f) Product of (b) and (e). (g) Histogram of (f). (h) Segmentation of red components in (a).

Color distance on the RGB color space (1)

a b c

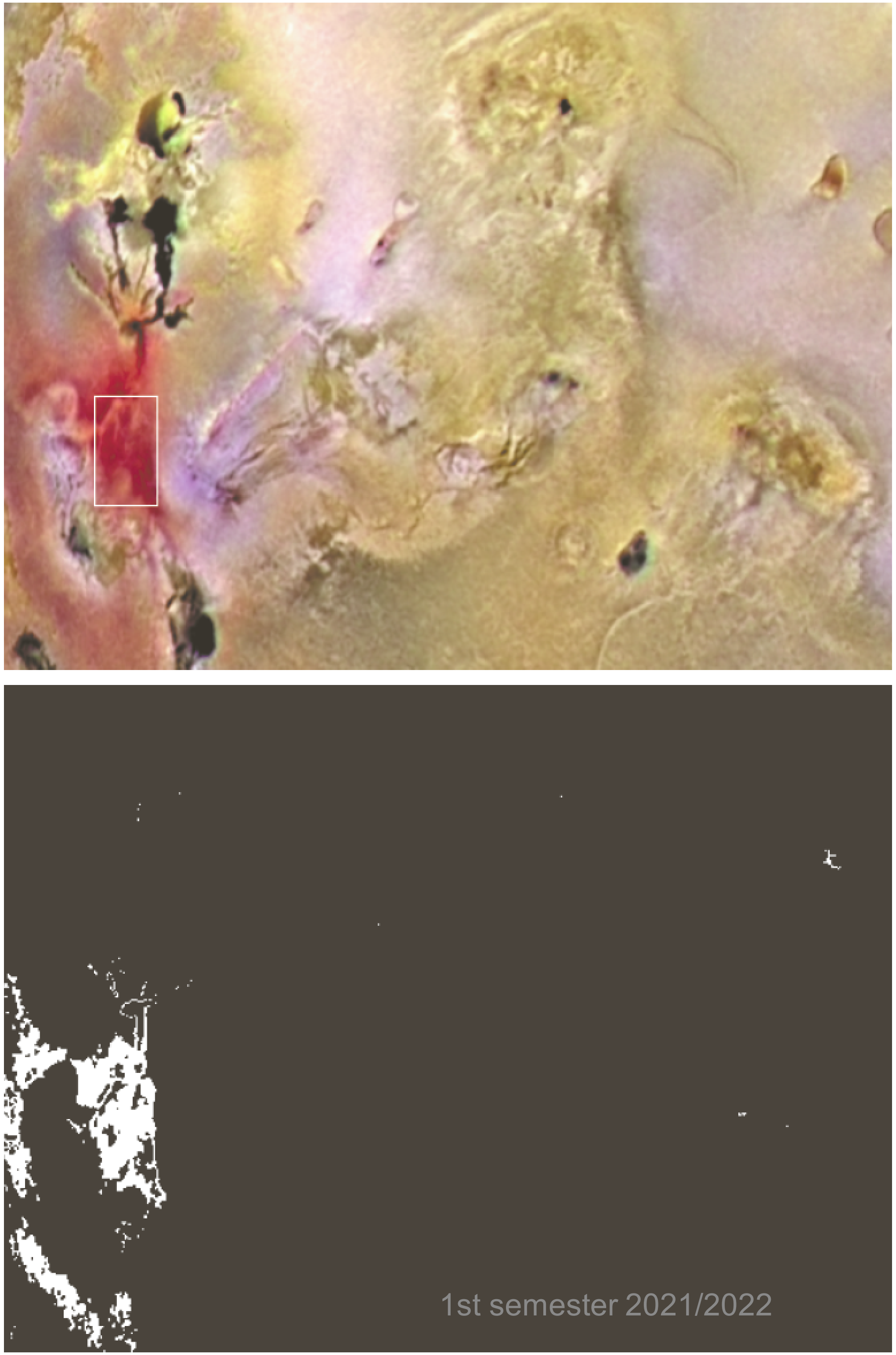
FIGURE 6.43 Three approaches for enclosing data regions for RGB vector segmentation.



Color distance on the RGB color space (2)

- Let cref = [Rref Gref Bref] be the reference color on the RGB color space
- Let c = [R G B] be some color on the RGB color space
- The **Euclidean distance** between these two colors (vectors) is

$$dist(c, cref) = \sqrt{(R - Rref)^2 + (G - Gref)^2 + (B - Bref)^2}$$



a
b

FIGURE 6.44
Segmentation in RGB space. (a) Original image with colors of interest shown enclosed by a rectangle. (b) Result of segmentation in RGB vector space. Compare with Fig. 6.42(h).

a b
c d

FIGURE 6.46
(a) RGB image.
(b) Gradient computed in RGB color vector space.
(c) Gradients computed on a per-image basis and then added.
(d) Difference between (b) and (c).

Gradient

a b c

FIGURE 6.47 Component gradient images of the color image in Fig. 6.46. (a) Red component, (b) green component, and (c) blue component. These three images were added and scaled to produce the image in Fig. 6.46(c).

Noise (RGB space)

a	b
c	d

FIGURE 6.48
(a)–(c) Red, green, and blue component images corrupted by additive Gaussian noise of mean 0 and variance 800. (d) Resulting RGB image. [Compare (d) with Fig. 6.46(a).]

Noise
(HSI Space)

a b c

FIGURE 6.49 HSI components of the noisy color image in Fig. 6.48(d). (a) Hue. (b) Saturation. (c) Intensity.

Salt&Pepper Noise
(On the G component)

a	b
c	d

FIGURE 6.50 (a) RGB image with green plane corrupted by salt-and-pepper noise. (b) Hue component of HSI image. (c) Saturation component. (d) Intensity component.

The effects of lossy encoding (JPEG)

a
b

FIGURE 6.51 Color image compression. (a) Original RGB image. (b) Result of compressing and decompressing the image in (a).

The effects of lossy encoding (JPEG)

Original

JPEG

Exercises (1)

In Portuguese. Exercício 3 do 2.º teste parcial, verão 2016/2017, 5 de junho de 2017

3. Considere o processamento de imagens coloridas.

   a) {1,5} Sejam as técnicas *color-slicing* e segmentação (*segmentation*) aplicadas a imagens coloridas. Indique: em que consistem as principais diferenças entre estas técnicas; o tipo de imagem (colorida, monocromática ou binária) produzido como resultado da aplicação de cada técnica.

   b) {1,5} Seja o seguinte algoritmo.

```
Entrada: Imagem colorida representada no espaço de cores RGB, f_RGB[m,n].
Saída:   Imagem colorida representada no espaço de cores RGB, g_RGB[m,n].
1. f_RGB = 1.2 * f_RGB;
2. f_HSI = convert_RGB_to_HSI(f_RGB);
3. f_HSI = set_H_band(f_HSI, 0 );  /* Colocar o valor de H de todos os pixels com 0. */
4. g_RGB = convert_HSI_to_RGB(f_HSI).
5. Retornar g_RGB.
```

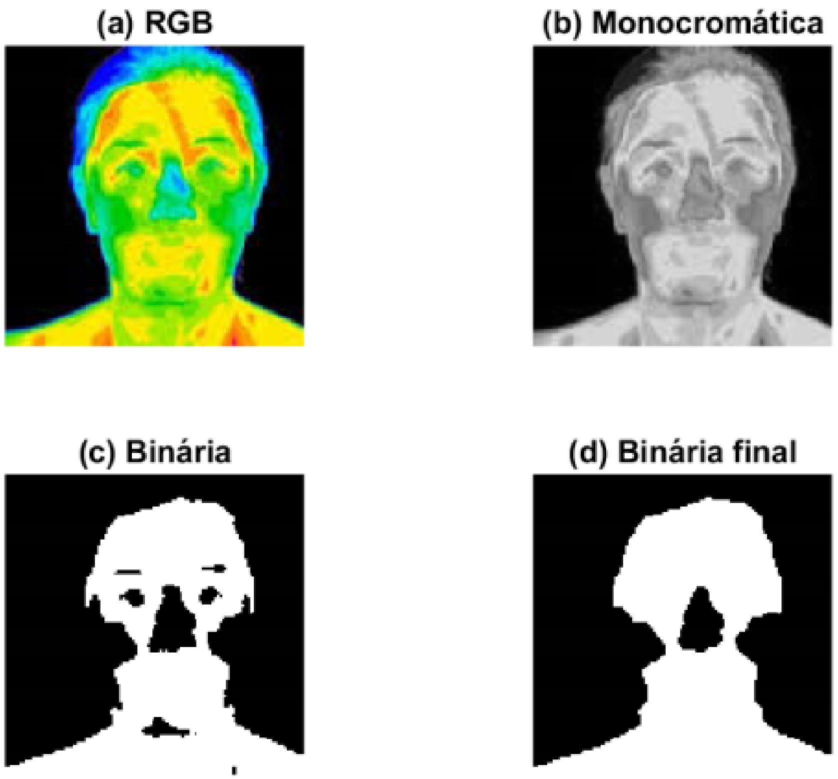
   Considerando que `f_RGB[m,n]` é uma imagem colorida com número muito elevado e distinto de cores, indique as principais diferenças entre `f_RGB[m,n]` e `g_RGB[m,n]`.

   c) {1,5} Considere que possui uma imagem colorida representada no espaço RGB, com pouca luminosidade e cores corretas. Indique, de forma detalhada, como procederia para corrigir este problema: i) no espaço RGB; ii) no espaço HSI.

Exercises (2)

In Portuguese. Exercício 4a do 2.º teste parcial, verão 2016/2017, 5 de junho de 2017

4. A figura apresenta quatro imagens:



(a) imagem RGB que representa um termograma facial;

(b) versão monocromática de (a);

(c) versão binária de (b);

(d) imagem binária com uma mancha que representa a área facial de temperaturas mais elevadas (excluindo as zonas frias da imagem).

a) {1,5} Caraterize o dispositivo e o processo físico que realiza a aquisição e a geração da imagem (a). Indique uma forma possível de obter a imagem (b), a partir da imagem (a).

Exercises (3)

In Portuguese. Exercício 8 do teste de época normal, verão 2016/2017, 22 de junho de 2017

8. {R2||TG} Considere o processamento de imagens coloridas.

   a) {1,5||1,0} Pretende-se implementar a função/método `numColors = uniqueColors (RGBImage Iin)`, a qual determina o número de cores distintas numa imagem colorida representada no espaço RGB. Indique, de forma detalhada, como procederia para realizar este algoritmo.

   b) {1,5||1,0} Pretende-se implementar a função/método `numGrayLevels = uniqueGrayLevels (RGBImage Iin)`, a qual determina o número de níveis de cinzento distintos numa imagem colorida representada no espaço RGB. Indique, de forma detalhada, como procederia para realizar este algoritmo.

   c) {1,25||1,0} Considere que se pretende realizar a operação de *smoothing* sobre uma imagem RGB, através de um filtro de média 3×3. Indique como procederia para efetuar esta operação: i) no espaço RGB; ii) no espaço HSI.

Bibliography

- The images displayed in these slides are from:

  - R. Gonzalez, R. Woods, *Digital Image Processing*, 4th edition, Prentice Hall, 2018, ISBN 0133356728
  - S. Smith, *The Scientist and Engineer's Guide to Digital Signal Processing*, Newnes, 2003, ISBN 0-750674-44-X [chapter 23]
  - O. Filho, H. Neto, Processamento Digital de Imagens, Rio de Janeiro: Brasport, 1999, ISBN 8574520098.
  - Wikipedia and Mathworks web pages
