Compedium-CV

Original document by: Tomás Alves - ist175541
Translated by: Afonso Carvalho - ist193681
& Martim Afonso - ist192522

April 17, 2022

Chapters I & II

Basics of image processing

1. Select the correct option for each of the following sentences.
   (a) An example of mid-level image processing is ...
      i. ... noise reduction;
      ii. ... image enhancement;
      iii. ... highlighting of features;
      iv. ... region classification (image segmentation).

      Answer: _____

   (b) The structuring elements of the human eye responsible for photopic vision are the ...
      i. ... retinas;
      ii. ... rod cells;
      iii. ... cone cells;
      iv. ... corneas.

      Answer: _____

   (c) The structuring elements of the human eye sensitive to light are ...
      i. ... retinas;
      ii. ... rod cells;
      iii. ... cone cells;
      iv. ... cornea.

      Answer: _____

(d) Which of the following elements is not part of the photometric model?

i. ... source of light;
ii. ... object on the surface;
iii. ... sensor;
iv. ... digital scanner.

Answer: _____

(e) The amount of light reflected by an object varies between ...

i. ... 0 and $+\infty$;
ii. ... 0 and 1;
iii. ... -1 and 1;
iv. None of the above.

Answer: _____

(f) The dominant color in the Bayer filter is ...

i. ... red;
ii. ... green;
iii. ... blue;
iv. ... white.

Answer: _____

(g) In computer vision, sampling consists in ...

i. ... digitizing the co-ordinate values of an image;
ii. ... digitizing the amplitude values of an image;
iii. ... applying a threshold operation;
iv. ... changing the magnification value.

Answer: _____

(h) The following expression for distances between pixels, D[p(x,y), q(s,t)] = |x-s| + |y-t|, is called ...

i. ... Euclidean distance;
ii. ... City-block distance;
iii. ... Chessboard distance;
iv. ... Point-to-point distance.

Answer: _____

(i) Which of the following codes represent the code 1011101100 in RLE format?

i. 1(1)1(0)3(1)1(0)2(1)2(1);
ii. 1(1)0(1)1(3)0(1)1(2)1(2);
iii. 6(1)4(0);
iv. None of the above.

Answer: _____

(j) Which of the following can be considered a type of low-level image processing?

i. Region description;
ii. Image enhancement;
iii. Scene interpretation;
iv. Region classification.

Answer: _____

(k) The structuring elements of the human eye responsible for scotopic vision are the ...

i. ... retinas;
ii. ... rod cells;
iii. ... cone cells;
iv. ... corneas.

Answer: _____

(l) The structuring elements of the human eye sensitive to color are the...

i. ... retinas;
ii. ... rod cells;
iii. ... cone cells;
iv. ... corneas.

Answer: _____

(m) The element that is part of the PDI system is ...

i. ... the light source;
ii. ... the surface element;
iii. ... the sensor;
iv. ... the human eye.

Answer: _____

(n) The amount of light that strikes an object varies between ...

i. ... 0 and $+\infty$;
ii. ... 0 and 1;
iii. ... -1 and 1;
iv. None of the above.

Answer: _____

(o) The dominant color in the Bayer filter is green because ...

i. ... we are more sensitive to green;
ii. ... the combination of blue with red results in green;
iii. ... the visible spectrum has more shades of green;
iv. ... it avoids chromatic distortion.

Answer: _____

(p) In computer vision, quantizaion consists in ...

i. ... digitizing the co-ordinate values of an image;
ii. ... digitizing the amplitude values of an image;
iii. ... applying a threshold operation;
iv. ... changing the magnification value.

Answer: _____

(q) The following expression for distances between pixels, D[p(x,y), q(s,t)] = max(|x-s|, |y-t|), is called ...

i. ... Euclidean distance;
ii. ... City-block distance;
iii. ... Chessboard distance;
iv. ... Point-to-point distance.

Answer: _____

(r) How many bits are required to represent 128 different intensity values in a digital image?

i. 8 bits;
ii. 7 bits;
iii. 6 bits;
iv. 128 bits.

Answer: _____

2. Knowing that an object O is 5 meters away from the camera and that two points placed in the same plane as the object are 0.5 meters apart, what's the corresponding distance of those points in the image plane?
   Consider the focal distance f to be 5 millimeters.

3. A point P as the following co-ordinates (x,y,z) = (6,8,2) in world space. Knowing that the focal distance f' is equal to 3, determine the corresponding co-ordinates of P'(x',y',z') in the retina space.

Chapters III

Binary image analysis

4. Consider the following representation of a digital image in Figure 1.

4	7	6	3	7
8	9	5	4	8
5	9	6	2	4
7	8	1	3	7
4	2	5	9	8

Figure 1

(a) Fill Figure 2 with the result of applying I $>$ 6, where I corresponds to Figure 1.

Figure 2

(b) Apply the CCA algorithm, considering a connectivity of 4, to Figure 2, and place the results on Figure 3.

Figure 3

5. Consider the following masks M, N and O, which correspond to Figures 4, 5 and 6, respectively. Also consider Figure 7 as image F

0	1	0
1	1	1
0	1	0

Figure 4

1	1	1
1	0	1
1	1	1

Figure 5

1
1
0

Figure 6

1	1	1	0	1	0	1
1	0	1	0	1	1	1
1	1	1	0	0	0	0
1	0	1	0	0	0	0
0	0	0	0	0	1	1
1	1	1	0	0	1	0
1	0	1	1	0	1	1

Figure 7

(a) Apply F $\oplus$ M and fill Figure 8 with the results.

Figure 8

(b) Apply F $\bigcirc$ N and fill Figure 9 with the results.

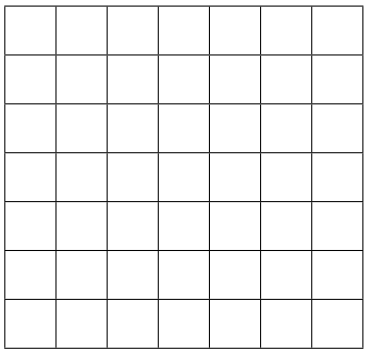

Figure 9

(c) Apply (F$\ominus$O)$\oplus$|FM and fill Figure 10 with the results.

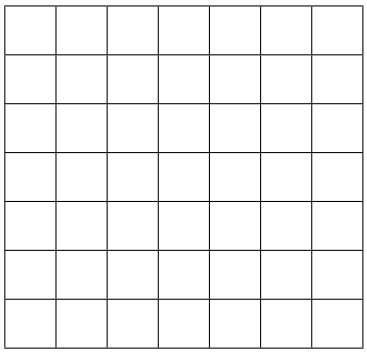

Figure 10

6. Consider the matrix in Figure 11.

2	3	5	4	2
4	6	9	1	1
1	6	2	4	6
7	8	4	5	7
2	4	2	1	3

Figure 11

(a) Fill Figure 12 with the result of applying I $>$ 4, where I corresponds to Figure 11.

Figure 12

(b) Apply the algorithm for detecting corners in Figure 12 and write down the number of external corners, internal corners and number of objects.

i. Number of external corners: _____

ii. Number of internal corners: _____

iii. Number of objects: _____

7. Consider the following matrix on Figure 13. Using an algorithm for building Region Adjacent Graphs, fill Figure 14 with the results and draw the resulting graph. Consider a connectivity of 4.

1	1	1	0	1	1	1
1	0	1	0	1	0	1
1	1	1	0	1	1	1
1	1	0	0	0	0	0
1	1	0	1	1	1	1
1	1	0	1	0	0	1
0	0	0	1	1	1	1

Figure 13

Figure 14

8. Consider the following matrix on Figure 15.

1	2	1	4
4	3	2	2
2	2	5	2
5	3	4	1

Figure 15

(a) Determine the histogram of Figure 15.

i. h = [ ]

(b) Using the Otsu algorithm, determine the threshold t and its "goodness".

i. t = _____

ii. λ = _____

Chapters IV

Image Preprocessing

9. State what is:
   (a) Image Enhancement:

   (b) Image Restauration:

10. State 3 techniques for image enhancement:
    (a) _____
    (b) _____
    (c) _____

11. State 2 techniques for image restauration:
    (a) _____
    (b) _____

12. Consider the matrix in Figure 16, in which 16 different levels of intensities (I) are possible. Fill in Table 1 with the cumulative distribution of pixels (CDF) and their equalized intensity (IQ)

10	6	8	4	8	9
5	12	6	3	1	8
7	10	4	4	8	12
14	5	16	10	12	3

Figure 16

I	CDF	IQ
1		
3		
4		
5		
6		
7		
8		
9		
10		
12		
14		
16		

Table 1

13. Recall the properties of bitmask operations. Select the correct options for each statement.

(a) Regarding differential operators, the mask co-ordinates must have _____ signs in order to obtain a _____ output whenever intensity transitions exist.

i. ...opposite...maximum;

ii. ...opposite...minimum;

iii. ...equal...maximum;

iv. ...equal...minimum;

Answer: _____

(b) Regarding smoothness operators, the mask M x N elements are _____ and their sum equals _____ in order for the output to be equal to the input regions with constant intensity

i. ...positive...M x N;
ii. ...negative...-M x N;
iii. ...symmetrical...0;
iv. None of the above;

Answer: _____

(c) Abrupt transitions are _____ sparse the _____ the mask dimensions are.

i. ...more...smaller;
ii. ...more...larger;
iii. ...less...larger;
iv. None of the above;

Answer: _____

14. Consider the following matrix in Figure 17.

1	6	4	8
5	3	2	6
7	1	5	4
6	2	3	4

Figure 17

(a) Fill the matrix in Figure 18 with the result of applying a mean filter on Figure 17 with a 3x3 mask. Only apply the filter if the mask overlaps all bits in the matrix.

Figure 18

(b) Fill the matrix in Figure 19 with the result of applying a median filter on Figure 17 with a 3x3 mask. Only apply the filter if the mask overlaps all bits in the matrix.

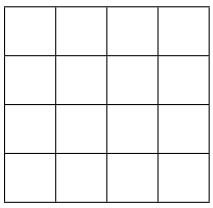

Figure 19

15. Recall the different kernels for edge detection.

(a) Fill the matrix in Figure 20 with one of the Prewitt's kernels

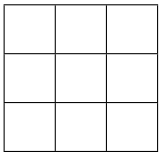

Figure 20

(b) Fill the matrix in Figure 21 with one of the Sobel's kernels

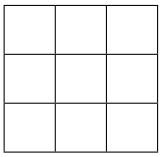

Figure 21

Chapters V

Color and Texture Extraction

16. Select the correct option for each of the following sentences
    (a) Following a structural approach, a texture is ...
        i. ... the way how a set of basic patterns are organized in a region;
        ii. ... a quantitative measure of how the intensities are arranged in a region;
        iii. ... a relation between a number of pixels and a certain luminous intensity;
        iv. None of the above.

        Answer: _____

    (b) What's the following color (255, 255, 0) in the CMY model?
        i. ... cyan;
        ii. ... magenta;
        iii. ... green;
        iv. ... blue;

        Answer: _____

    (c) Let D be the color (123, 214, 21) in RGB. The chrominance value for red is...
        i. ...0.66;
        ii. ...0.33;
        iii. ...0.34;
        iv. ...123;

        Answer: _____

17. Consider the matrix in Figure 22. Write down the quantitative measures of density and edge orientation.
    (a) $F_{edgeness}$ = (___, ___)
    (b) F_{magdir} = (___, ___, ___)

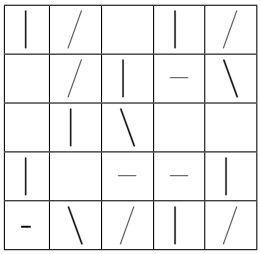

Figure 22

18. Consider the following color (123,44,202) in the RGB model.
    (a) Convert that color to the CMY model: (___,___,___);
    (b) State the chrominance value for each of the RGB model components:
        i. r = ___;
        ii. g = ___;
        iii. b = ___.
    (c) State the luminance of the RGB model: ___.
19. Consider the following histograms h_1 and h_2. State the value of the intersection$\{h_1, h_2\}$ and match$\{h_1, h_2\}$.
    h1 = [5 3 2 6 2 3]
    h2 = [4 3 1 4 3 1]
    (a) intersection$\{h_1, h_2\}$ = _____.
    (b) match$\{h_1, h_2\}$ = _____..

Chapters VI

Motion Analysis

20. State two image subtraction methods.
    (a) _____.
    (b) _____.

21. State the 5 steps of the simple algorithm for region detection.
    (a)
    _____
    _____

    (b)
    _____
    _____

    (c)
    _____
    _____

    (d)
    _____
    _____

    (e)
    _____
    _____

22. Name 3 phenomena between bounding boxes that might occur in a video surveillance system

(a) _____.

(b) _____.

(c) _____.

23. Observe images 1 e 2. How can you differentiate the active regions to know if it's a car, a persona or another set of active pixels?

_____

_____

Image 1

Image 2

Chapters VI

Region Segmentation

24. Name 3 possible features to segment regions

    (a) _____.

    (b) _____.

    (c) _____.

25. Build the quadtree of the binary image represented in Fig. 23, according with Fig. 24.

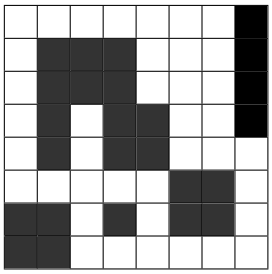

Figure 23

1	2
3	4

Figure 24

26. Name the 4 steps of the canny algorithm.

(a) _____.

(b) _____.

(c) _____.

(d) _____.

27. Build the polygonal approximation of the following *chaincode* in Figure 25. Begin in the designated dot.
chaincode: 101776655242432

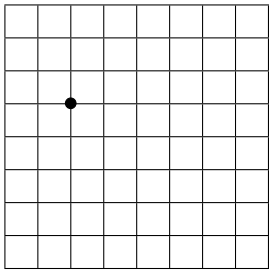

Figure 23

3	2	1
4		0
5	6	7

Figure 24

28. Using the matrices ThetaQ and DQ in Figures 27 and 28 respectively, fill the Accumulator matrix in Figure 29.
NOTE: Assume that in the Accumulator matrix, ThetaQ has intervals of 10 and DQ intervals of 1.

-	-	0	0	-
-	-	0	0	-
90	90	40	20	-
90	90	60	40	-
-	-	-	-	-

Figure 27

-	-	3	3	-
-	-	3	3	-
3	3	3	3	-
3	3	3	3	-
-	-	-	-	-

Figure 28

Figure 29

29. Given the Tables 2, 3 and 4, each corresponding to the lines and angles of a certain point, write down the angle and approximated distance, rounding to decimal places, of a line connecting all three points.

Angle	Dist.
0	40.0
30	69.6
60	81.2
90	70.0
120	40.6
150	0.4

Table 2

Angle	Dist.
0	57.1
30	79.5
60	80.5
90	60.0
120	23.4
150	-19.5

Table 3

Angle	Dist.
0	74.6
30	89.6
60	80.6
90	50.0
120	6.0
150	-39.6

Table 4

(a) Angle: _____.

(b) Distance: _____.

30. Analyse Figure 30.

(a) Draw the MST of the tree.

(b) What is the value of $Int(\mathrm{C})$?
$Int(\mathrm{C}) =$ _____.

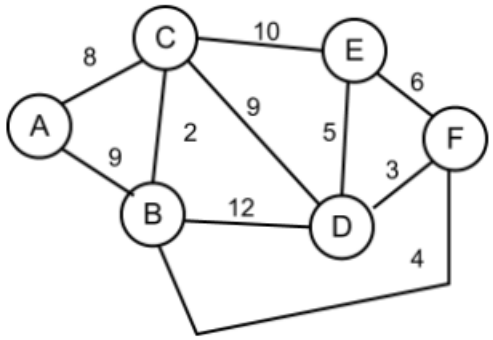

Figure 30