

Computer Vision I: Homework 6

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1 Problem description

Write a program which counts the **Yokoi connectivity number** on a downsampled image (lena.bmp).

Hint:

1. Binarize the benchmark image Lena as in HW2 by 128.
2. Using 8×8 blocks as a unit, take the topmost-left pixel as the down-sampled data, Down-sample Lena from 512×512 to 64×64 .
3. Count the Yokoi connectivity number.
4. Result of this assignment is a 64×64 matrix. Please align the matrix within 1 single A4 page (using 4-connected).

2 Yokoi connectivity number

Our goal is to determine the connective numbers of each pixel by the given binary image. There are six types of labels of connective numbers, shown in Table 1. For convenience, we denote the corner neighborhoods corresponding to 8 directions of each center pixel in Table 2.

Label	Type
0	Isolated
1	Edge
2	Connecting
3	Branching
4	Crossing
5	Interior

Table 1: Label of connective numbers.

x_7	x_2	x_6
x_3	x_0	x_1
x_8	x_4	x_5

Table 2: Neighborhoods of center pixel.

We defined the function h to represent how the center pixel connects to the neighborhood pixels in 2×2 block.

$$h(b, c, d, e) = \begin{cases} q, & \text{if } b = c \text{ and } d \neq b \text{ or } e \neq b, \\ r, & \text{if } b = c \text{ and } d = b \text{ and } e = b, \\ s, & \text{if } b \neq c \end{cases}$$

where r express when all pixels of the region are 255, q express when the main axis is 255, but one of the neighborhoods is 0, and s expresses other cases. We calculus the h value of 4 main axis (x_1, x_2, x_3, x_4) as the following.

$$\begin{aligned} a_1 &= h(x_0, x_1, x_6, x_2), \\ a_2 &= h(x_0, x_2, x_7, x_3), \\ a_3 &= h(x_0, x_3, x_8, x_4), \\ a_4 &= h(x_0, x_4, x_5, x_1) \end{aligned}$$

Finally, we defined function f to determine the connectivity number. If all the neighbors are equal to r , it represents the interior, so the label is 5. Otherwise, the label is the number of q .

$$f(a_1, a_2, a_3, a_4) = \begin{cases} 5, & a_1 = a_2 = a_3 = a_4 = r, \\ n(\{a_k \mid a_k = q\}), & \text{otherwise} \end{cases}$$

3 Experiment result

11111111	121111111111122322221	111111111111	0 0
15555551	11555555511 2 11 11	115555555511	0
15555551	1 2115555112 21112221	155555555551	21
15555551	1 2 155112 2221511	155555555511	1
15555551	22 2112 22 121 0 0	1555555555511	0
15555551	1 2 21 2 1 1	1555555555551	0
15555551	12 1 121111 1321	15555555555511	
15111551	1322 1155551111	15555555555551	
111 1551	1 121555555511	155555555555511	
11 1551	2115555511	1551115555511	
21 1551	2 15555555111	1551 11555511	
1 1551	2 155555555511	1551 115551	1
1551	112115555555551	1551 15511	12
1551	1555555555555511	1551 1111	111
1551	1 222115555555555511	1151 11	1151
1551	2 22 1 1555555555555511	151 11111	1551
1551	2 1 11555555555555551	151 115551	11551
1551	2 1155555555555555111511155511		115551
1551	12 115555555555555555555555551		155551
1551	11 0 22155555555555555555555555112		1155551
1551	111 22 1555555555555555555555551	1	1555551
1551	1511 1 125112111112111555555555111		1155551
1551	15521 1 121 1 11 1 15555555111	0	1555551
1551	1151 132 2 11555555111	0	11555551
1551	151 0 322 115555111	121	15555551
1551	1221 2 155551	131	115555551
1551	2 0 1 11555511	1	115555551
1551	2 0 0 115555551	0	1 15555551
1551	2 1155555551		2115555551
1551	1 0 11555555551		1555555551
1551	1 1151111555521	1	11555555551
1551	1 1 11111 1155511	2	15555555551
1551	131 111 15111	2	15555555551
1551	121 0 1121 1 111 1	2	115555555551
1551	11 111 1 221 11 1	2	155555555551
1551	12 0 1 21 121 11 1111	2	155555555551
1551	1 12 22 151111111551	2	1155555555551
1551	1 2 1555551115511	1	1555555555551
1551	2 0 0 22 12555551 15551	1	1555555555551
1551	1 1 1555511 11511	2	11555555555551
1551	0 0 21 155551 1 151	2	15555555555551
1551	2 15555112 151	2	15555555555551
1551	1 1 1 1155555511111	2	15555555555551
1551	2 22 111511111212		211555555555551
1551	0 1 12 151 2 1		1555555511155551
1551	0 0 0 1111 121		15555551 155551
1551	0 11111111		15555551 155551
1551	0 115551		15555551 1555511
1551	15551		211111111 155511
11521	1 12 122155511	2	11 115511
1 151 0	1 1 155555111	2111	15511
22 1511	1 15555555111	155111	1511
22 1511	1 1555555551	155551	1151
2 151	0 1 11155555555511	155511	1511
2 1521	0 1 155555555555511	15551	12151
2 151	121 15555555555551	155511	1551
2 1511	0 155555555555551	115551	1511
21 1511	11 15555555555551		111111151
11 151	0 1155555555555511		111511
11 151	1555555555555551		151
11 151	0 1155555555555551		211
11 151	115555555555555511		1
11 151	0 1555555555555551		
11 111	0 1211111111111111111		

Figure 1: Yokoi connectivity number

4 Summary

In this homework, we use the Yokoi algorithm to calculate the connectivity number, which is a nonrecursive symbolic neighborhood operator method to classify the pixel into six type labels. As we have shown in Figure 1, this figure doesn't have label 4.