

Problem 4a: Determine the 3x3 binary pixel grid for a bifurcation point:

b2	b3	b4
b1		b5
b0	b7	b6

$$\text{Crossing Number} = \frac{1}{2} \sum_{i \in \{1 \dots 7\}} |b_i - b_{(i+1)\%8}|$$

$$CN = \frac{1}{2} * (|1 - 0| + |0 - 0| + |0 - 1| + |1 - 0| + |0 - 0| + |0 - 1| + |1 - 0| + |0 - 1|)$$

$$CN = \frac{1}{2} * (|1| + |0| + |-1| + |1| + |0| + |-1| + |1| + |-1|)$$

$$CN = \frac{1}{2} * (1 + 0 + 1 + 1 + 0 + 1 + 1 + 1)$$

Crossing Number = 3 ; therefore a bifurcation point.

Problem 4b: Determine the 3x3 binary pixel grid for a non-minutiae point

b2	b3	b4
b1		b5

b0	b7	b6
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$$\text{Crossing Number} = \frac{1}{2} \sum_{i \in \{1 \dots 7\}} |b_i - b_{(i+1)\%8}|$$

$$CN = \frac{1}{2} * (|0 - 0| + |0 - 1| + |1 - 0| + |0 - 0| + |0 - 0| + |0 - 1| + |1 - 0| + |0 - 0|)$$

$$CN = \frac{1}{2} * (0 + 1 + 1 + 0 + 0 + 1 + 1 + 0)$$

Crossing Number = 2 ; even #of crossings therefore a non minutiae point.

Problem 5: The following image shows the values in grayscale. Perform the necessary steps to detect minutiae points. You don't need to detect any minutiae centered at the edge. Show your steps. Your result will include the coordinate of detected minutiae points and their types.

0	0	1	2	0	0	0	1	1	0
0	0	1	3	0	0	1	2	0	1
0	2	2	0	0	1	0	0	0	1
2	1	0	0	3	0	0	1	2	2
0	0	0	1	0	0	0	1	2	0
0	0	0	0	0	3	2	1	1	0
0	3	2	2	1	2	4	0	0	0
2	2	0	0	0	4	0	0	0	1
1	0	0	0	1	2	0	0	1	0
1	0	0	2	2	3	0	1	0	0

Removing noise from image by choosing a threshold of 3

If value is 3 or greater; replacing with 1

If value is below 3; replacing with 0

This yields the following:

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

And shown above in the circled region is a bifurcation point. The other points are either centered at the edge or they don't give a minutiae point.