Lecture 11: Region labelling

Giving a region a name

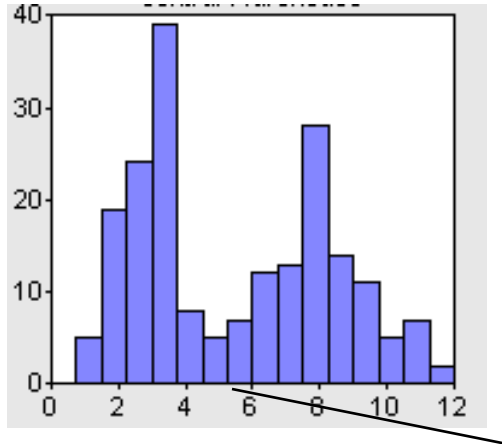
Binary Images

- Obtained from gray-level (or color) image g(x, y) by Thresholding

- Characteristic Function

$$b(x, y) = \begin{cases} 1 & \text{if } g(x, y) < T \\ 0 & \text{if } g(x, y) \geq T \end{cases}$$

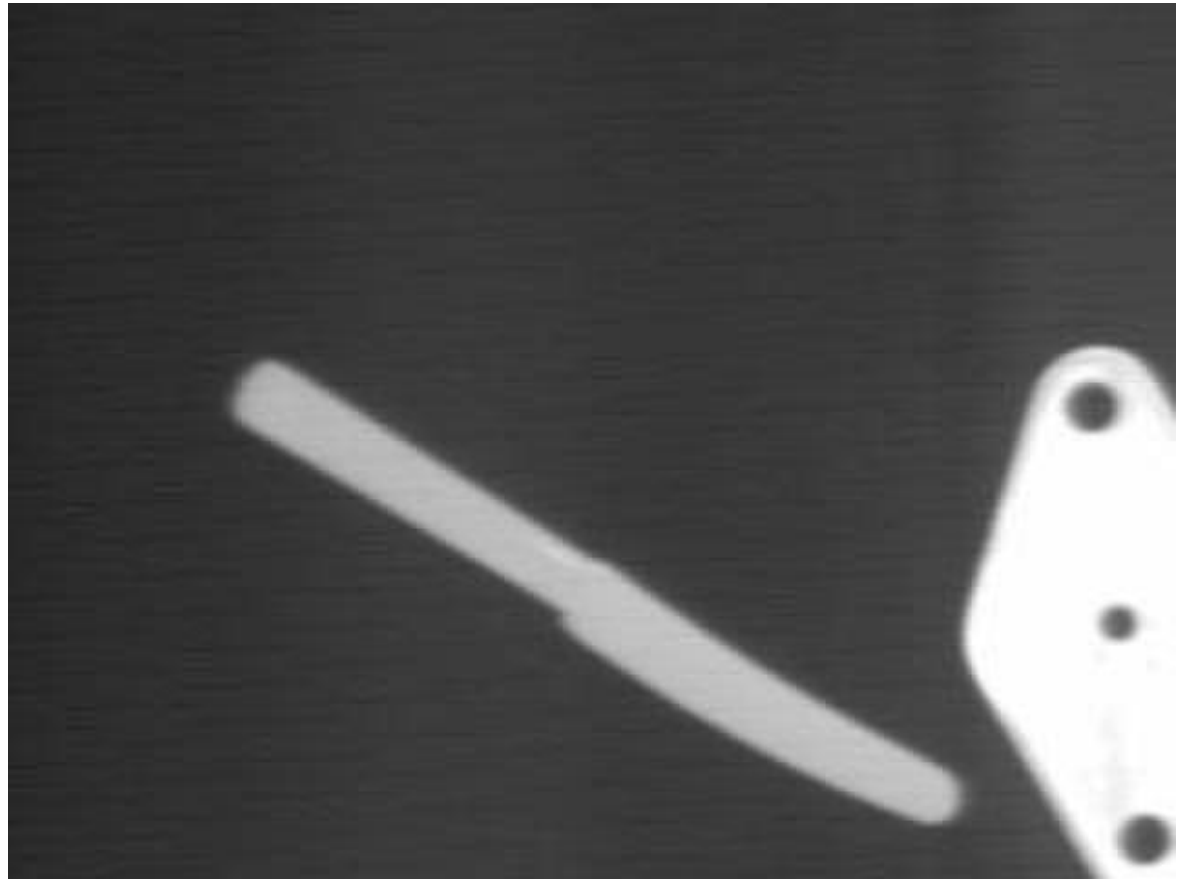
Selecting a Threshold



Bimodal Histogram

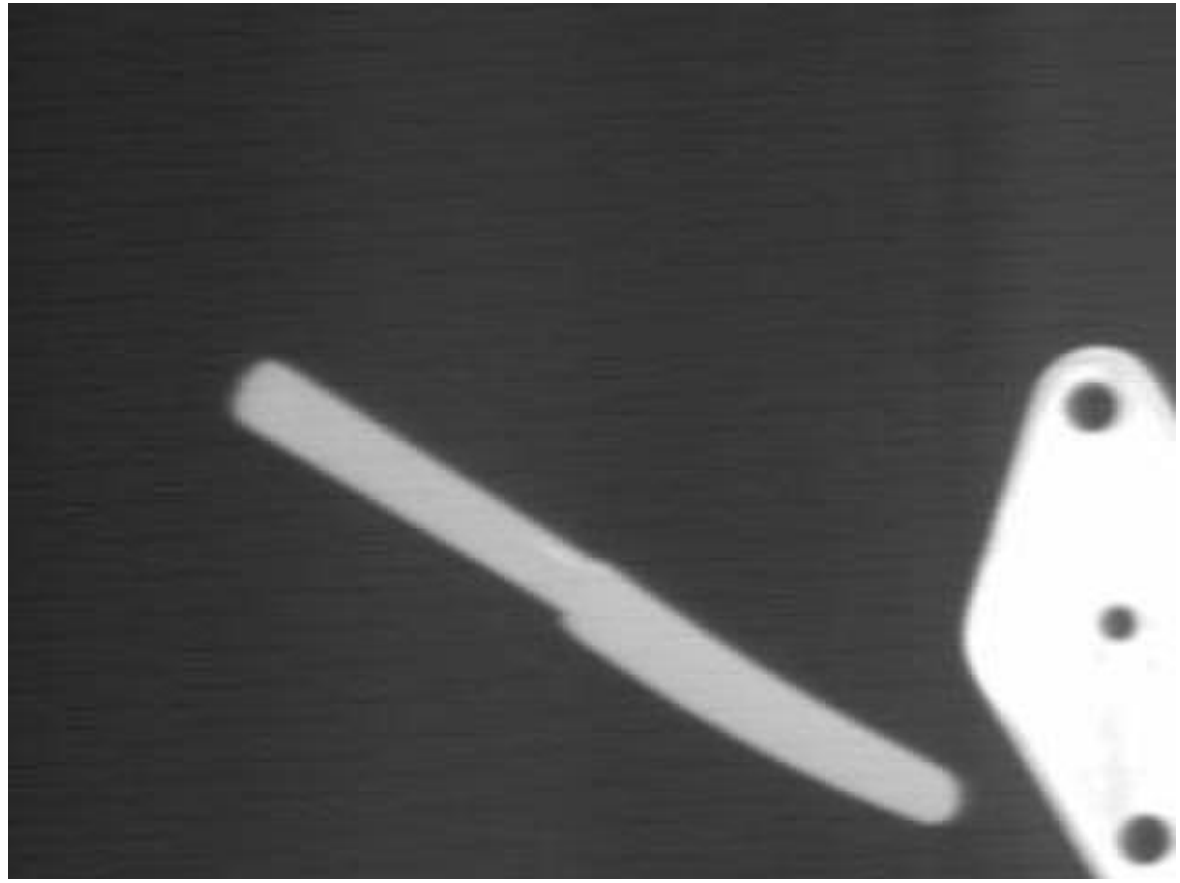
Threshold

Multiple Objects



Need to SEGMENT image into separate COMPONENTS (regions)

Multiple Objects



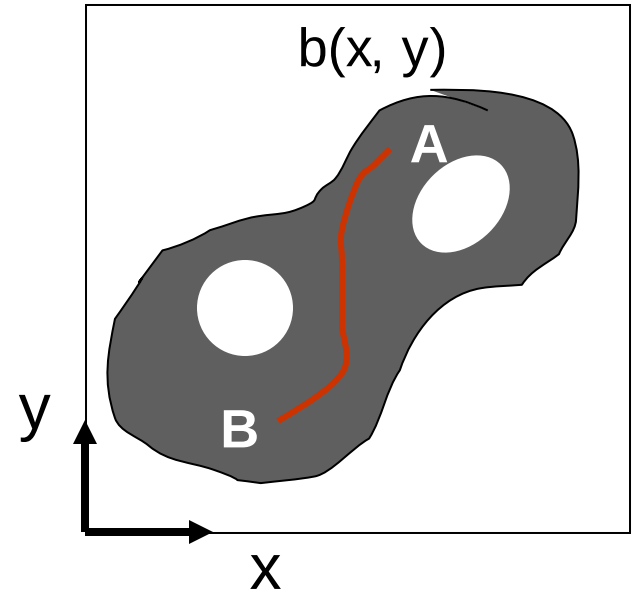
Need to SEGMENT image into separate COMPONENTS (regions)

Connected Components

Maximal Set of Connected points

Remember Graph Theory?

A & B are connected: Path exists between A & B along which b(x,y) is constant.



Connected Component Labeling

Region Growing Algorithm:

(a) Start with "SEED" point where b(x,y) = 1

(b) Assign LABEL to seed point

(c) Assign SAME LABEL to its Neighbors with b(x,y) = 1

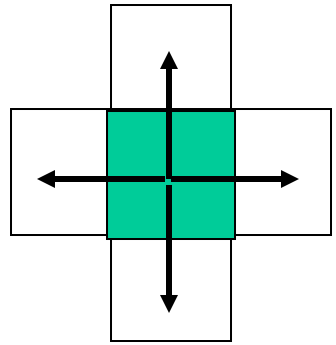
(d) Assign SAME LABEL to Neighbors of Neighbors

Terminates when a component is completely labeled.

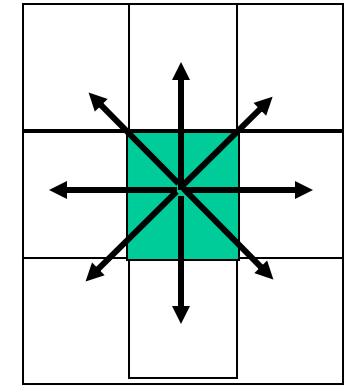
Then, pick another UNLABELED seed point.

What do we mean by Neighbors?

Connectedness:



4-connectedness

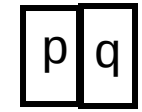


8-connectedness

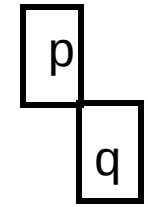
Neither is perfect!

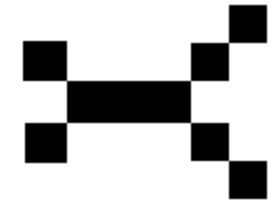
Adjacency

- **4-adjacency:** $q \in N_4(p)$



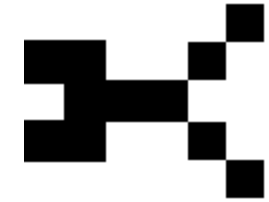
- **8-adjacency:** $q \in N_8(p)$



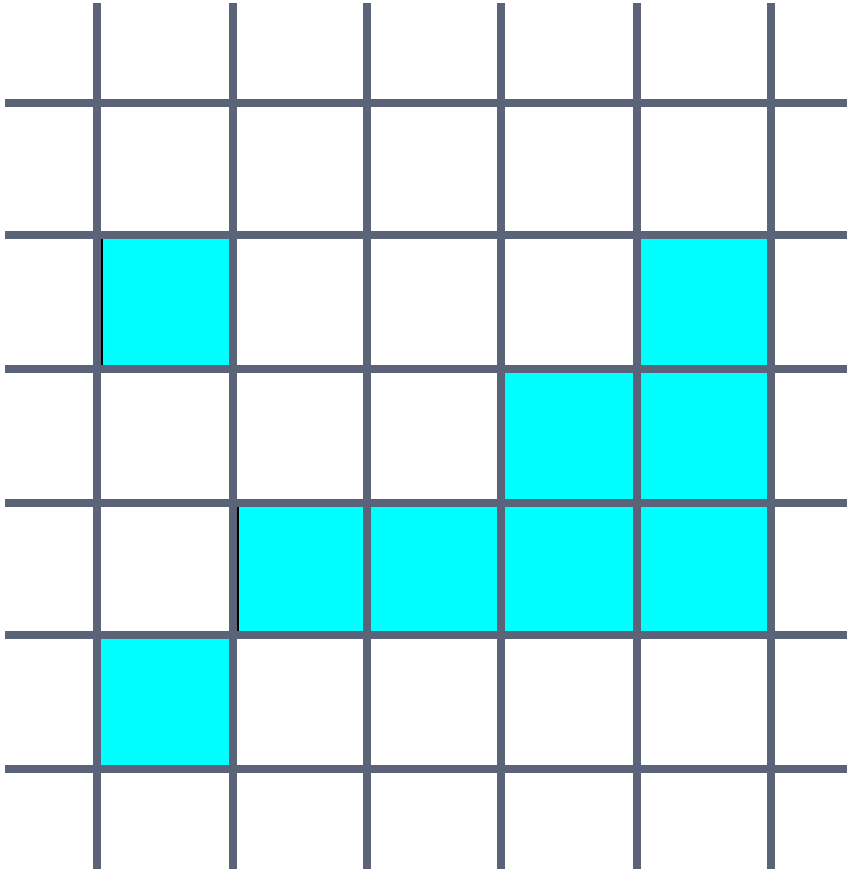


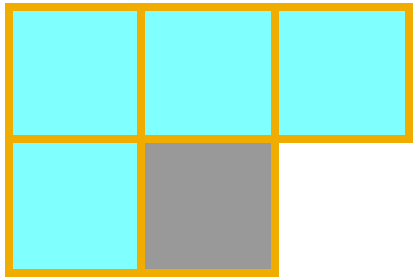
- **m-adjacency:** $q \in N_4(p)$ **or**

  $q \in N_D(p)$ **and** $N_4(p) \cap N_4(q) = \varnothing$



Region Labeling

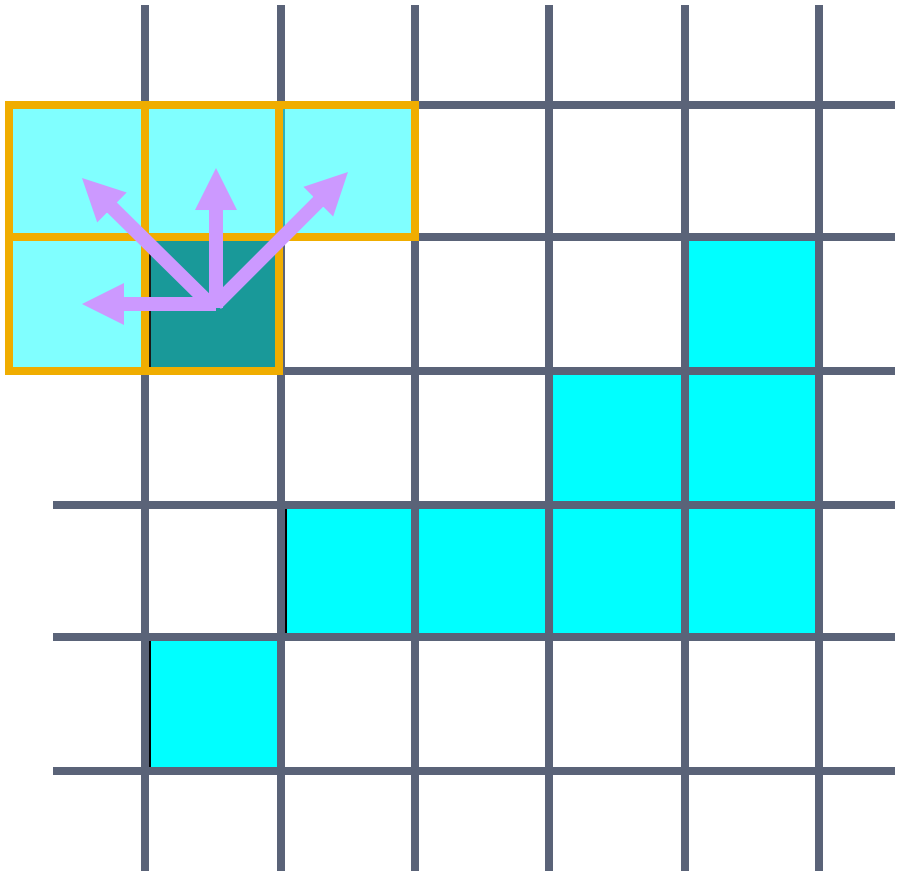




Equivalence Table

1	0
2	0
3	0
4	0
5	0

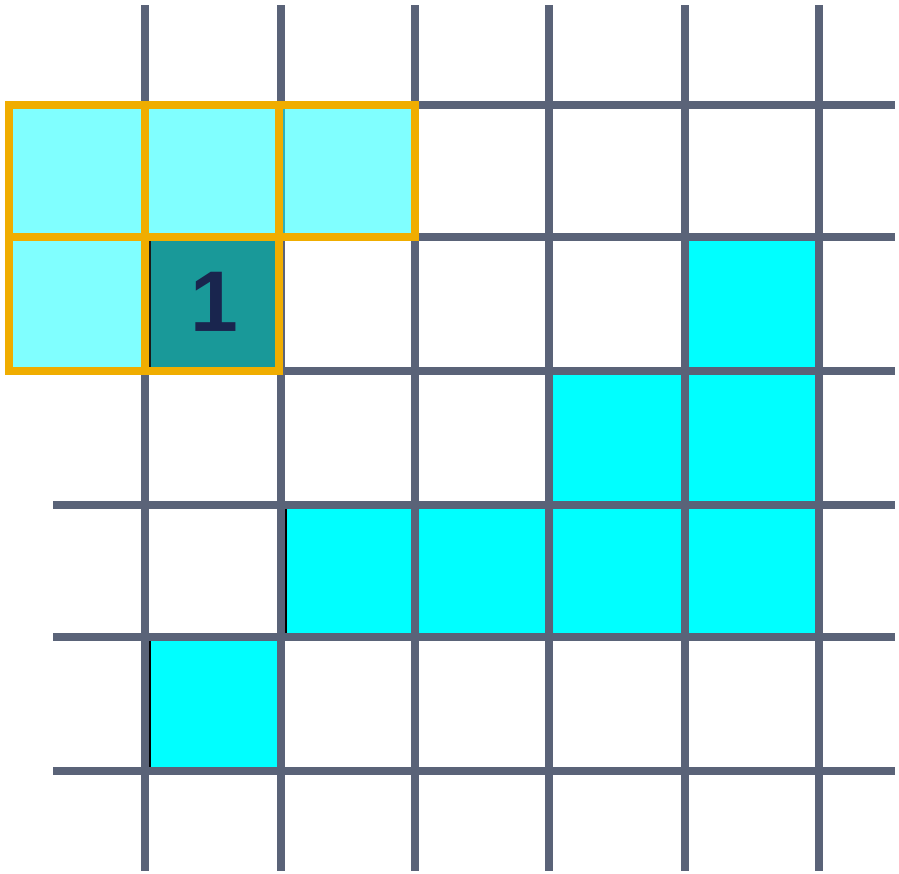
Region Labeling



Equivalence Table

1	0
2	0
3	0
4	0
5	0

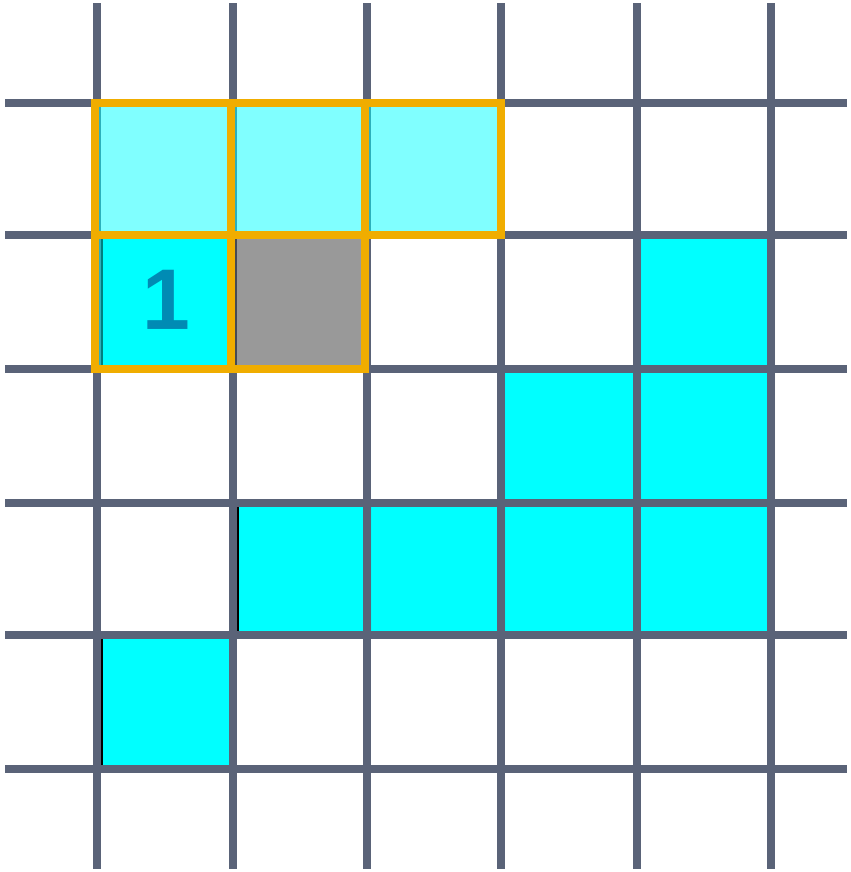
Region Labeling



Equivalence Table

1	1
2	0
3	0
4	0
5	0

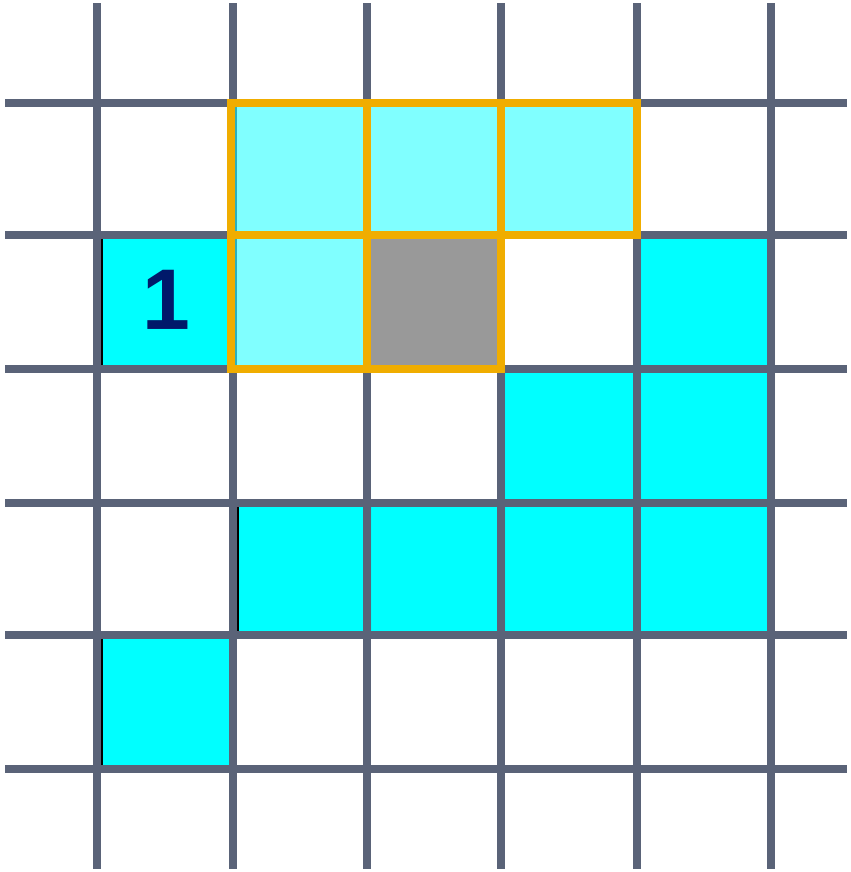
Region Labeling



Equivalence Table

1	1
2	0
3	0
4	0
5	0

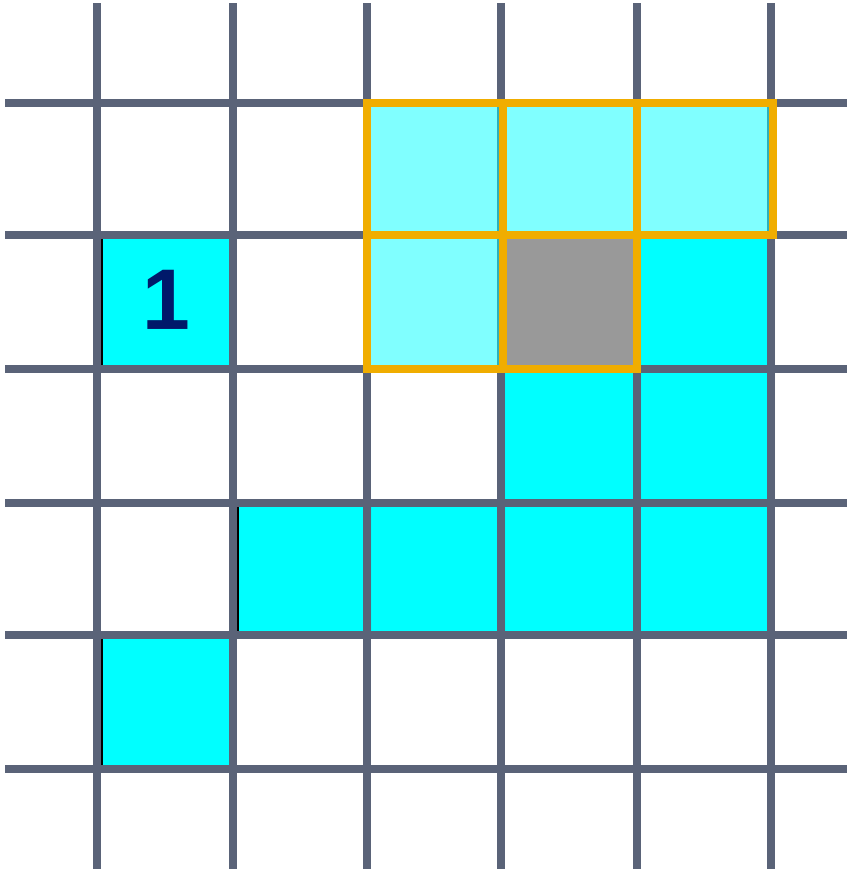
Region Labeling



Equivalence Table

1	1
2	0
3	0
4	0
5	0

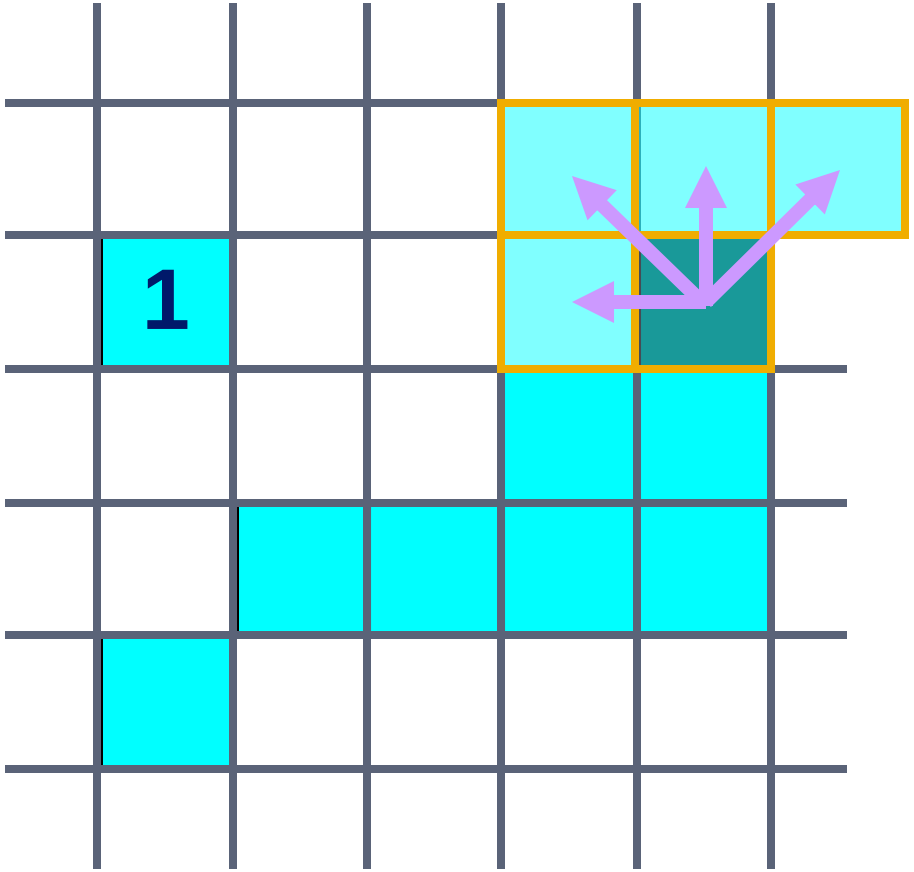
Region Labeling



Equivalence Table

1	1
2	0
3	0
4	0
5	0

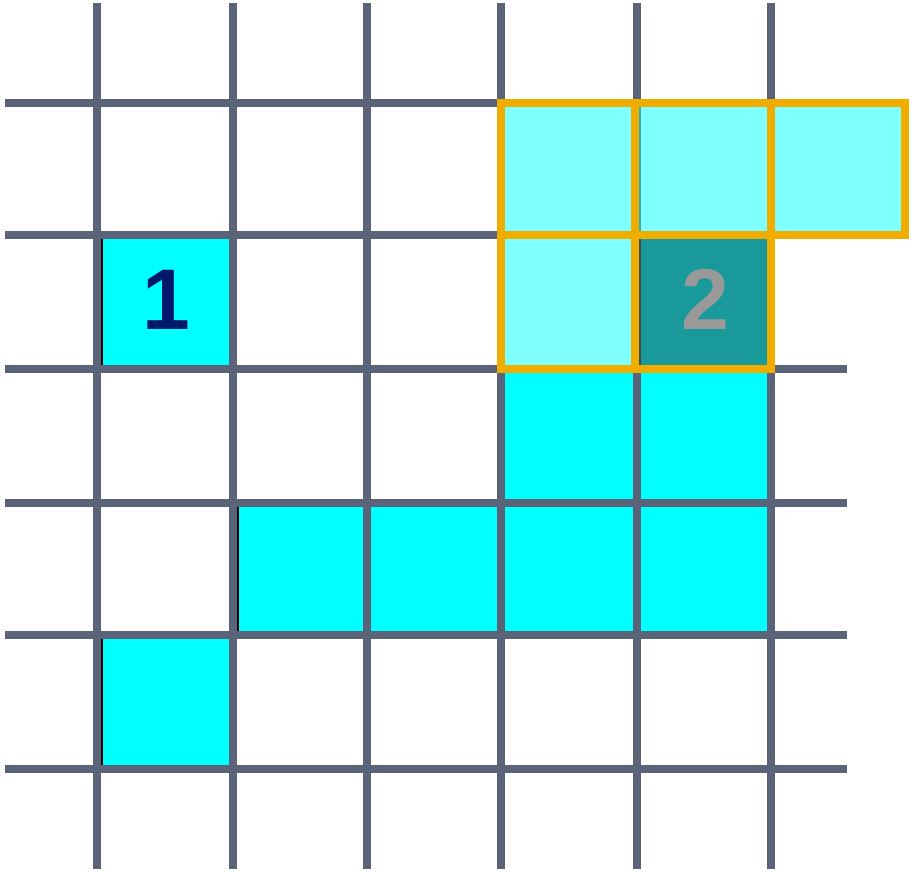
Region Labeling



Equivalence Table

1	1
2	0
3	0
4	0
5	0

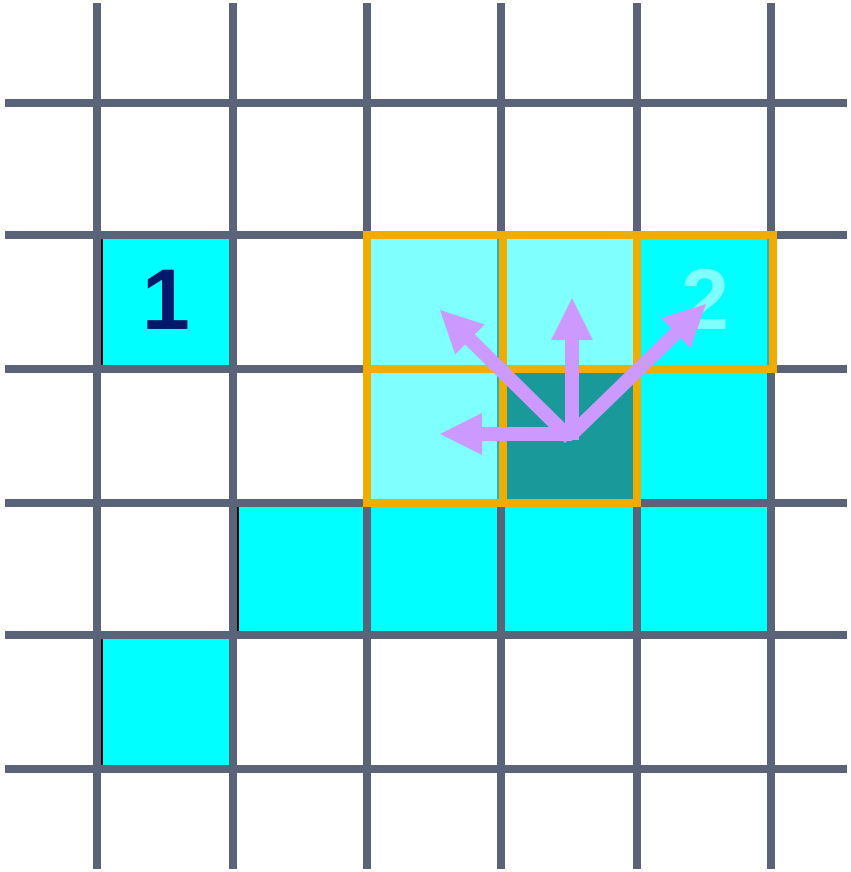
Region Labeling



Equivalence Table

1	1
2	2
3	0
4	0
5	0

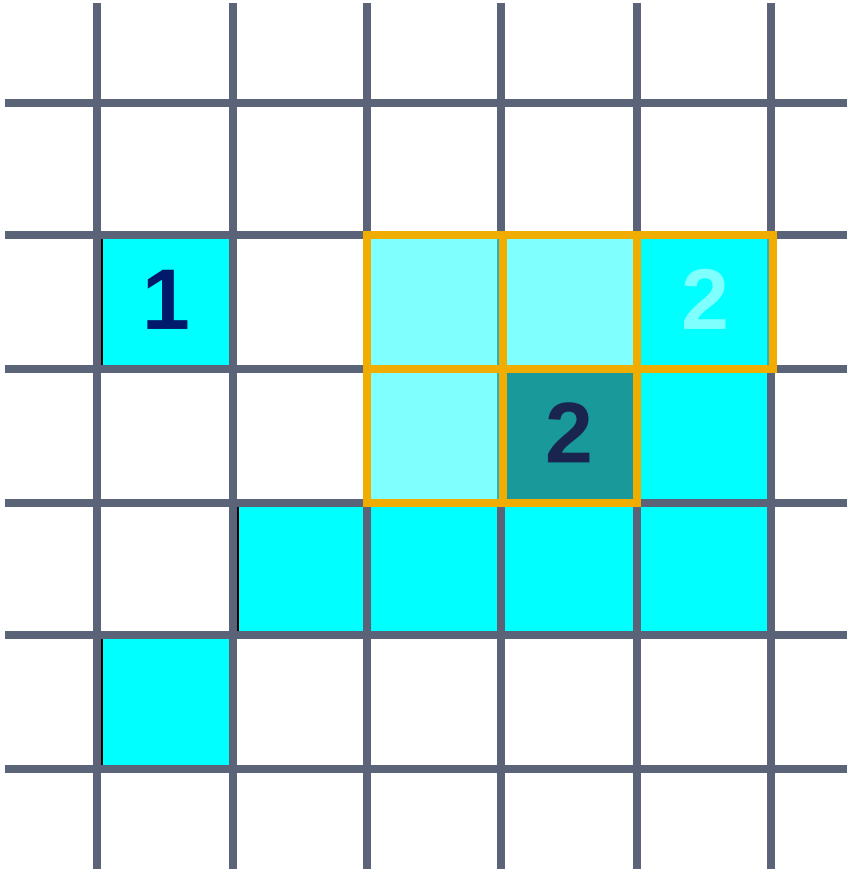
Region Labeling



Equivalence Table

1	1
2	2
3	0
4	0
5	0

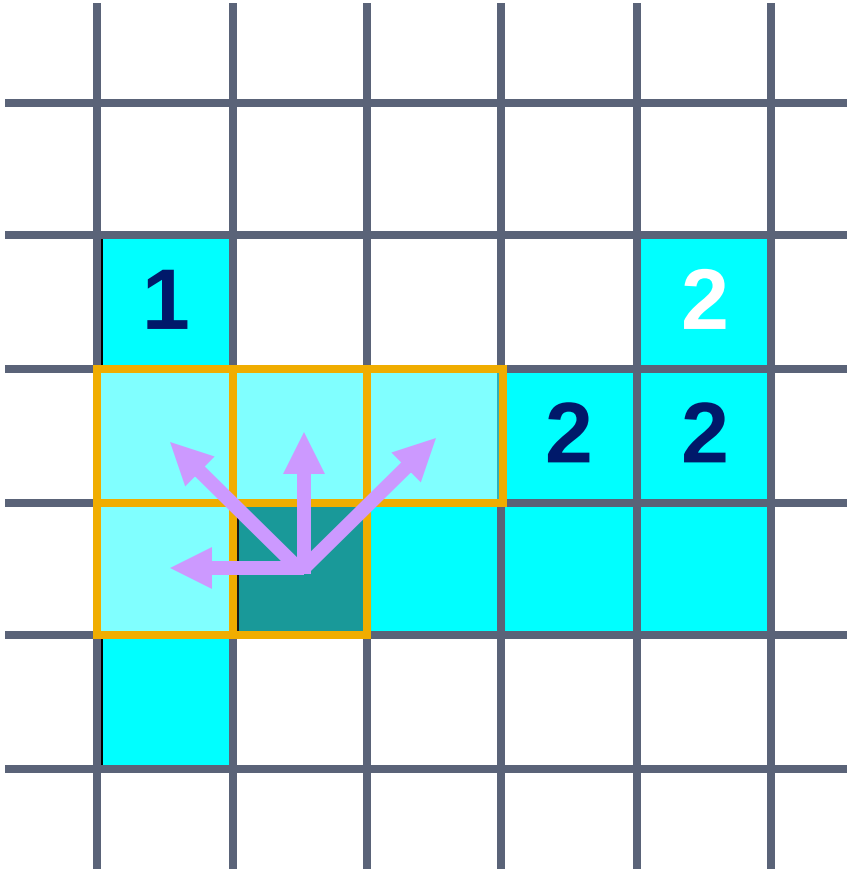
Region Labeling



Equivalence Table

1	1
2	2
3	0
4	0
5	0

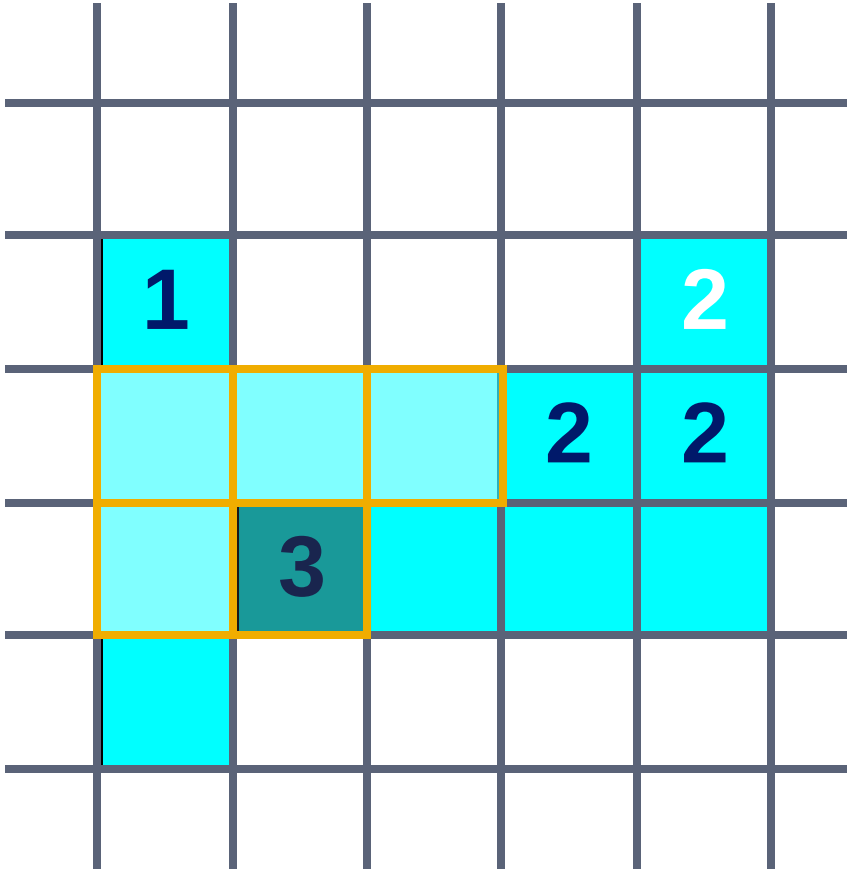
Region Labeling



Equivalence Table

1	1
2	2
3	0
4	0
5	0

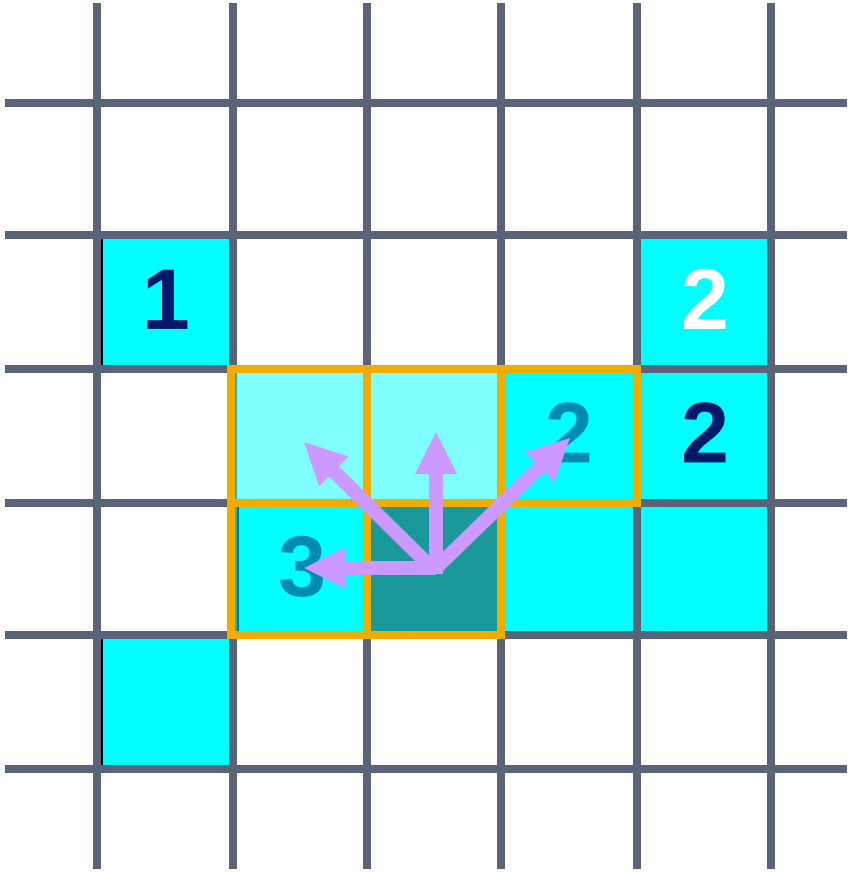
Region Labeling



Equivalence Table

1	1
2	2
3	3
4	0
5	0

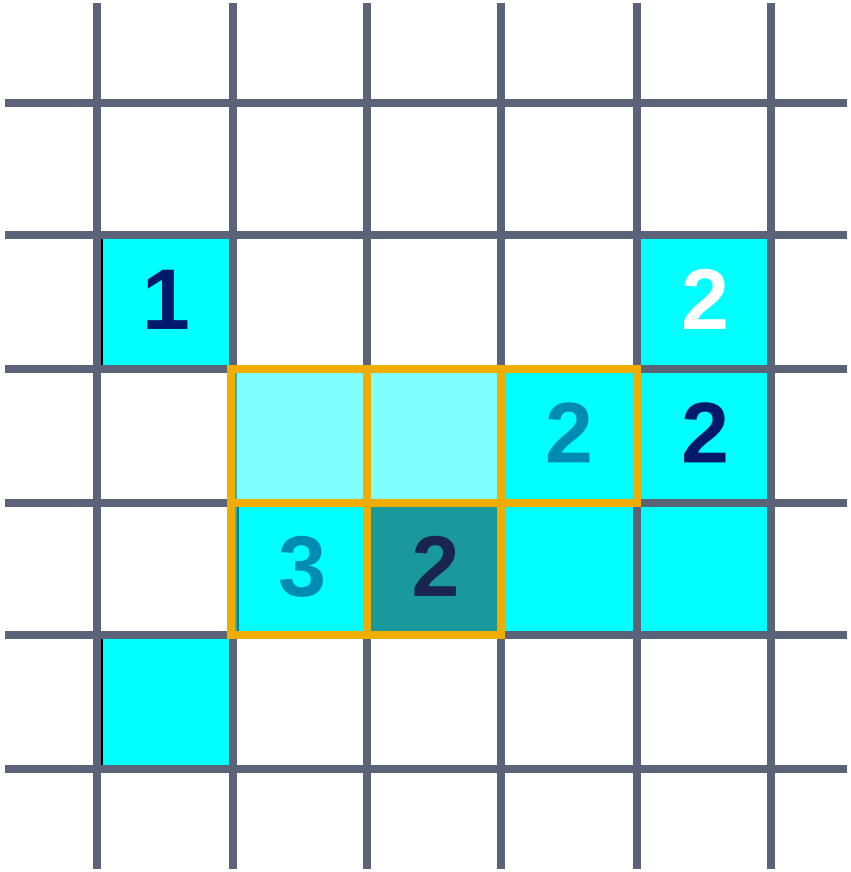
Region Labeling



Equivalence Table

1	1
2	2
3	3
4	0
5	0

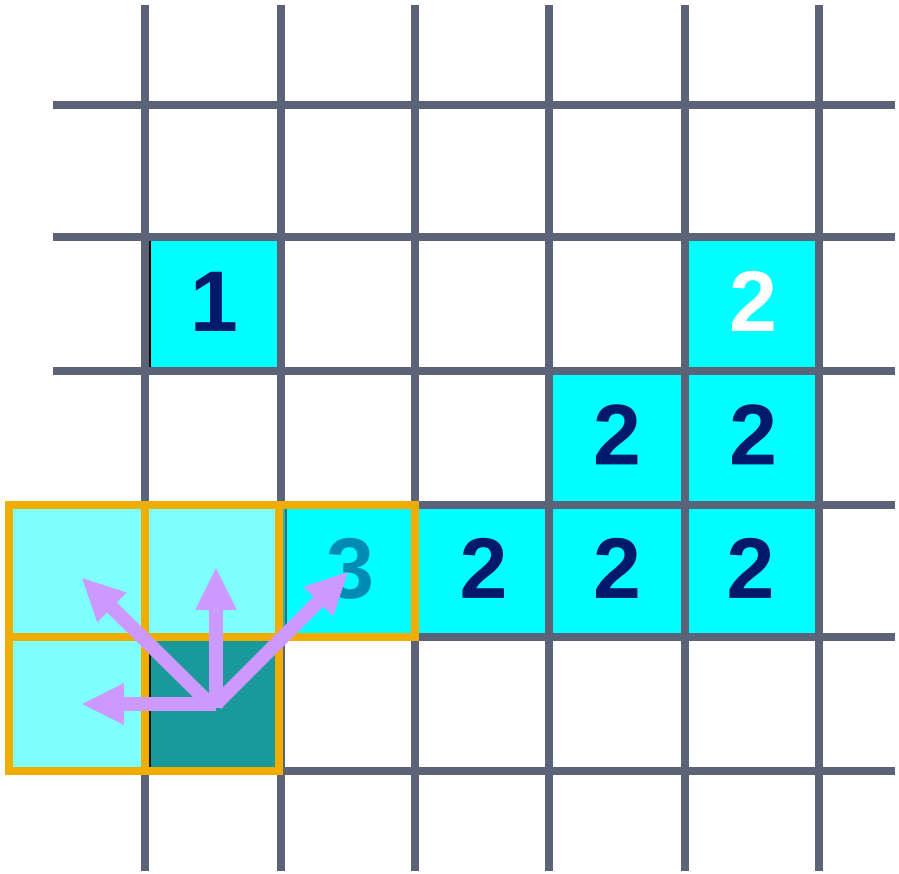
Region Labeling



Equivalence Table

1	1
2	2
3	2
4	0
5	0

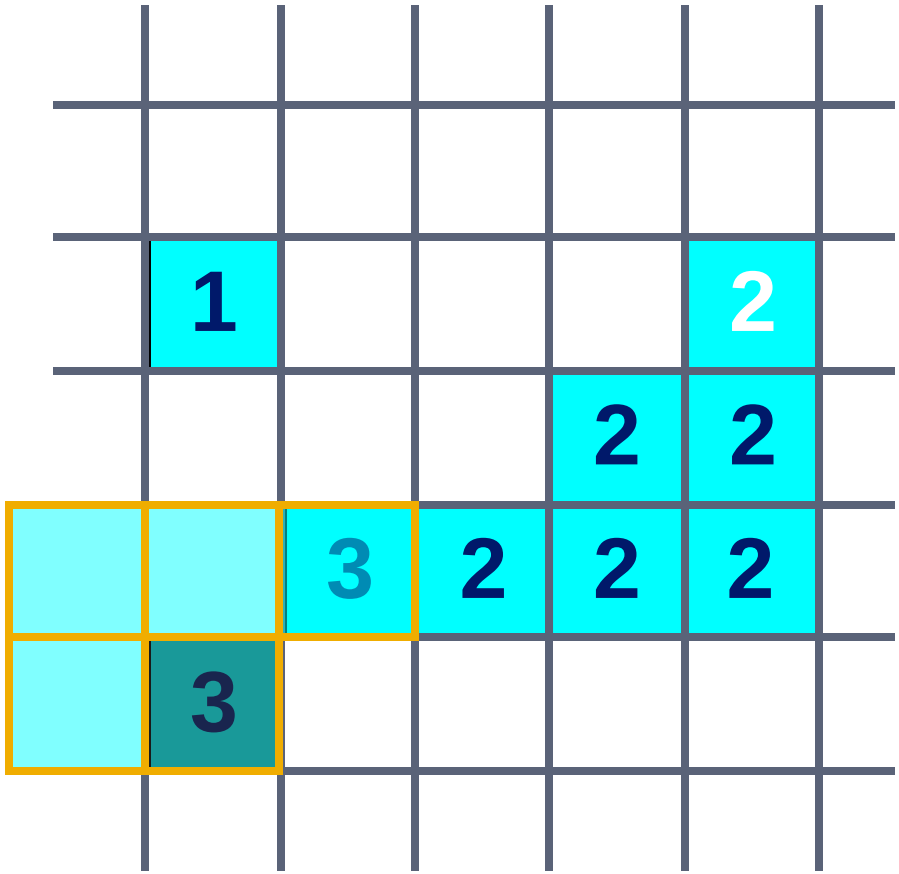
Region Labeling



Equivalence Table

1	1
2	2
3	2
4	0
5	0

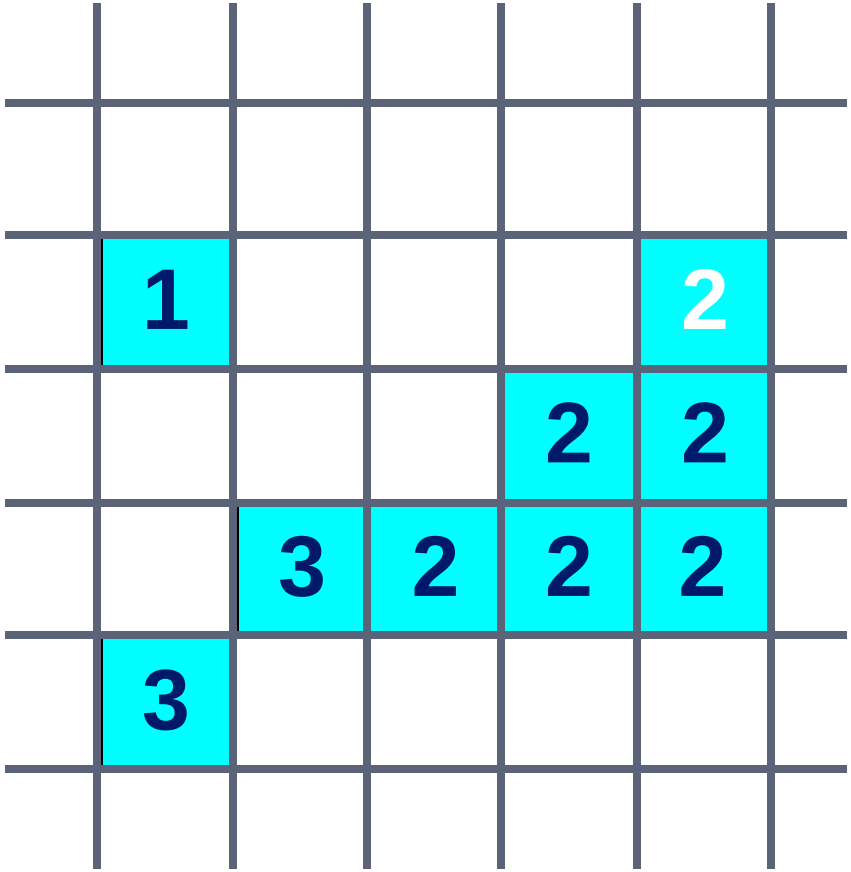
Region Labeling



Equivalence Table

1	1
2	2
3	2
4	0
5	0

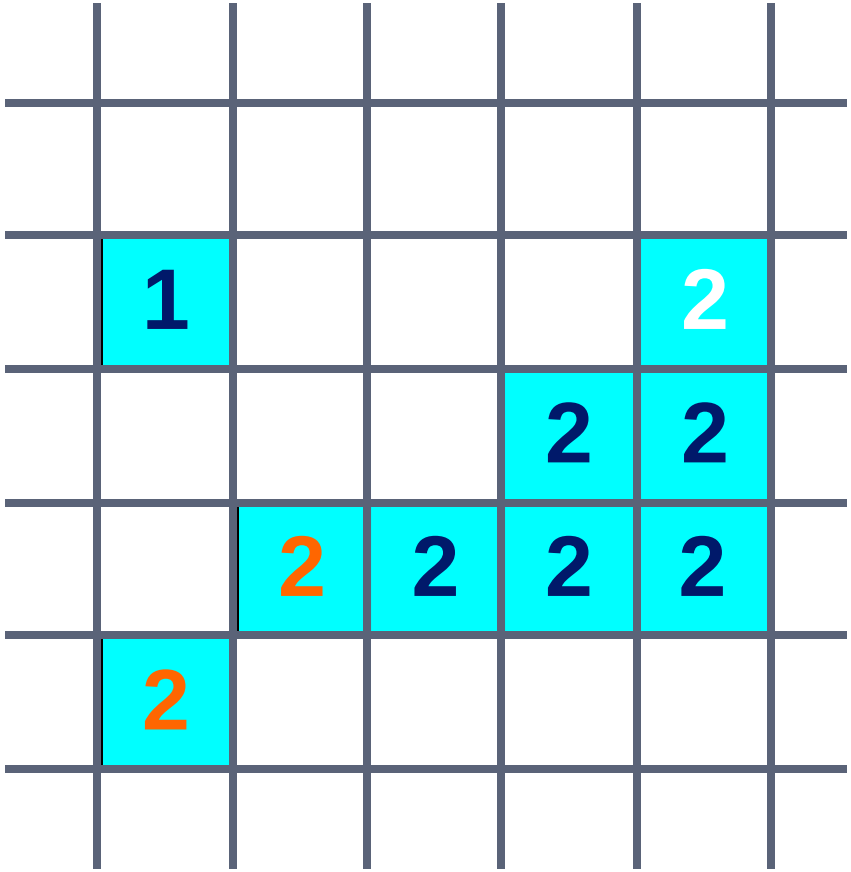
Region Labeling



Equivalence Table

1	1
2	2
3	2
4	0
5	0

Region Labeling



Equivalence Table

1	1
2	2
3	2
4	0
5	0

Equivalent Labels

The Labeling Process

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

Equivalent Labels

Region Labeling

Connected component labeling of binary image:

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

a) binary image

L

0	0	0	0	0	0	0	0
0	0	0	1	0	0	0	0
0	0	0	1	0	2	2	2
0	1	1	1	0	0	0	2
0	1	0	0	0	2	2	2
0	0	0	0	0	0	0	0

b) connected components labeling

Region Labeling

Connected component labeling of binary image:

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

a) binary image

1	1	0	1	1	1	0	2
1	1	0	1	0	1	0	2
1	1	1	1	0	0	0	2
0	0	0	0	0	0	0	2
3	3	3	3	0	4	0	2
0	0	0	3	0	4	0	2
5	5	0	3	0	0	0	2
5	5	0	3	0	2	2	2

b) connected components labeling

Region Properties

- Once a binary image has been processed we could obtain properties about the regions in the processed image.
- Some of those properties are
  - Area, centroid, perimeter, perimeter length, circularity of the region and second circularity measure

Area and Centroid

- Area A = sum of all the 1-pixels in the region.
- Centroid [r′,c′] is the average location of the pixels in the region
  - r′ = 1/A*Sum of all the rows in the region
  - c′ = 1/A*Sum of all the columns in the region.

Perimeter

- A simple definiton of the perimeter of a region without holes i set of its interior border pixels.

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

labeled connected-components image

region num.	region area	row of center	col of center	perim. length	circularity$_1$	circularity$_2$	radius mean	radius var.
1	44	6	11.5	21.2	10.2	15.4	3.33	.05
2	48	9	1.5	28	16.3	2.5	3.80	2.28
3	9	13	7	8	7.1	5.8	1.2	0.04

properties of the three regions