Level 2:
Select potential dark / bright objects

Given a set of objects (i.e. connected area of the same color), we want to determine which areas belong to the same crater.

Input: nrOfRows nrOfColumns   2D-image-data-with-ID-of-connected-areas   luminosity-table

nrOfRows = number of rows of the 2D image

nrOfColumns = number of cols of the 2D image

2D-image-data-with-ID-of-connected-areas = list of connected-area-IDs (with nrOfRows x nrOfColumns elements)

connected-area-ID = number; all pixels with same ID belong to the same connected area
0 used for background

luminosity-table = nrOfPairs   list-of-pairs

list-of-pairs = list of pairs (with nrOfPairs elements)

pair = ID   luminosity

ID = ID of the connected area (> 0), as in the image data above

luminosity = luminosity of that connected area as a number from 0 (for dark) .. 7 (for bright)

Output: Input of level 1 (i.e. image with just zeroes and ones)

Important Assumption

When you look on a crater picture the sun shines from the right.

Simple Example 1
(see also next page)

Input: 12 19 0 0 0 0 … data

```
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 2 2 2 2 0 1 1 1 1 1 0 0 0 0 0 0
0 0 2 2 2 2 2 0 1 1 1 1 1 1 0 0 0 0 0
0 0 2 2 2 0 0 1 1 1 1 1 1 1 0 0 0 0 0
0 0 2 2 2 0 0 1 1 1 1 1 1 0 0 0 0 0 0
0 0 2 2 2 0 0 1 1 1 1 1 1 0 0 0 0 0 0
0 0 2 2 2 0 0 1 1 1 1 1 1 1 1 0 0 0 0
0 0 2 2 2 0 0 1 1 1 1 1 1 1 1 0 0 0 0
0 0 2 2 2 2 0 1 1 1 1 1 1 1 1 0 0 0 0
0 0 2 2 2 2 0 0 1 1 1 1 1 1 1 0 0 0 0
0 0 0 2 2 2 2 0 1 1 1 1 1 1 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
```

```
2 1 1 2 7
```

luminosity-table

Output: 12 19 0 0 0 0 … data

```
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 1 1 1 1 1 0 0 0 0 0 0
0 0 1 1 1 1 1 0 1 1 1 1 1 1 0 0 0 0 0
0 0 1 1 1 0 0 1 1 1 1 1 1 1 0 0 0 0 0
0 0 1 1 1 0 0 1 1 1 1 1 1 0 0 0 0 0 0
0 0 1 1 1 0 0 1 1 1 1 1 1 0 0 0 0 0 0
0 0 1 1 1 0 0 1 1 1 1 1 1 1 1 0 0 0 0
0 0 1 1 1 0 0 1 1 1 1 1 1 1 1 0 0 0 0
0 0 1 1 1 1 0 1 1 1 1 1 1 1 1 0 0 0 0
0 0 1 1 1 1 0 0 1 1 1 1 1 1 1 0 0 0 0
0 0 0 1 1 1 1 0 1 1 1 1 1 1 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
```

Simple Example 1 (continued)

Input: 12 19 0 0 0 0 … data

```
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 2 2 2 2 0 1 1 1 1 1 0 0 0 0 0 0
0 0 2 2 2 2 2 0 1 1 1 1 1 1 0 0 0 0 0
0 0 2 2 2 0 0 1 1
0 0 2 2 2 0 0 1 1
0 0 2 2 2 0 0 1 1
0 0 2 2                       0 0 0 0
0 0 2 2                       0 0 0 0
0 0 2 2 2 2 0 1 1 1 1 1 1 1 1 0 0 0 0
0 0 2 2 2 2 0 0 1 1 1 1 1 1 1 0 0 0 0
0 0 0 2 2 2 2 0 1 1 1 1 1 1 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
```

Luminosity 1
dark

Luminosity 7
bright

2 1 1 2 7 luminosity-table

Output: 12 19 0 0 0 0 … data

```
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 1 1 1 1 1 0 0 0 0 0 0
0 0 1 1 1 1 1 0 1 1 1 1 1 1 0 0 0 0 0
0 0 1 1 1 0 0 1 1 1 1 1 1 1 0 0 0 0 0
0 0 1                       0 0 0 0 0
0 0 1                       0 0 0 0 0
0 0 1                       1 0 0 0 0
0 0 1                       1 0 0 0 0
0 0 1 1 1 1 0 1 1 1 1 1 1 1 1 0 0 0 0
0 0 1 1 1 1 0 0 1 1 1 1 1 1 1 0 0 0 0
0 0 0 1 1 1 1 0 1 1 1 1 1 1 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
```

Belongs to same crater (since sun shines from right to left)

Simple Example 2 (see also next page)

Input: 12 19 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 2 2 2 2 0 1 1 1 1 1 0 0 0 0 0 0
0 0 2 2 2 2 2 0 1 1 1 1 1 1 0 0 0 0 0
0 0 2 2 2 0 0 1 1 1 1 1 1 1 0 0 0 0 0
0 0 2 2 2 0 0 1 1 1 1 1 1 0 0 0 0 0 0
0 0 2 2 2 0 0 1 1 1 1 1 1 0 0 0 0 0 0
0 0 2 2 2 0 0 1 1 1 1 1 1 1 1 0 0 0 0
0 0 2 2 2 0 0 1 1 1 1 1 1 1 1 0 0 0 0
0 0 2 2 2 2 0 1 1 1 1 1 1 1 1 0 0 0 0
0 0 2 2 2 2 0 0 1 1 1 1 1 1 1 0 0 0 0
0 0 0 2 2 2 2 0 1 1 1 1 1 1 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
```

2 1 **7** 2 **1**

Output: 12 19 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 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 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 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
```

Simple Example 2 (continued)

Input: 12 19 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 2 2 2 2 0 1 1 1 1 1 0 0 0 0 0 0
0 0 2 2 2 2 2 0 1 1 1 1 1 1 0 0 0 0 0
0 0 2 2 2 0 0 1 1
0 0 2 2 2 0 0 1 1
0 0 2 2 2 0 0 1 1
0 0 2 2 0 0 0 0
0 0 2 2 0 0 0 0
0 0 2 2 2 2 0 1 1 1 1 1 1 1 1 0 0 0 0
0 0 2 2 2 2 0 0 1 1 1 1 1 1 1 0 0 0 0
0 0 0 2 2 2 2 0 1 1 1 1 1 1 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

Luminosity 7
bright

Luminosity 1
dark

2 1 **7** 2 **1**

Output: 12 19 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 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 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 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

Does not belong
to same crater

Advanced Example (see also next page)

Input: 12 19 0 0 0 0 …

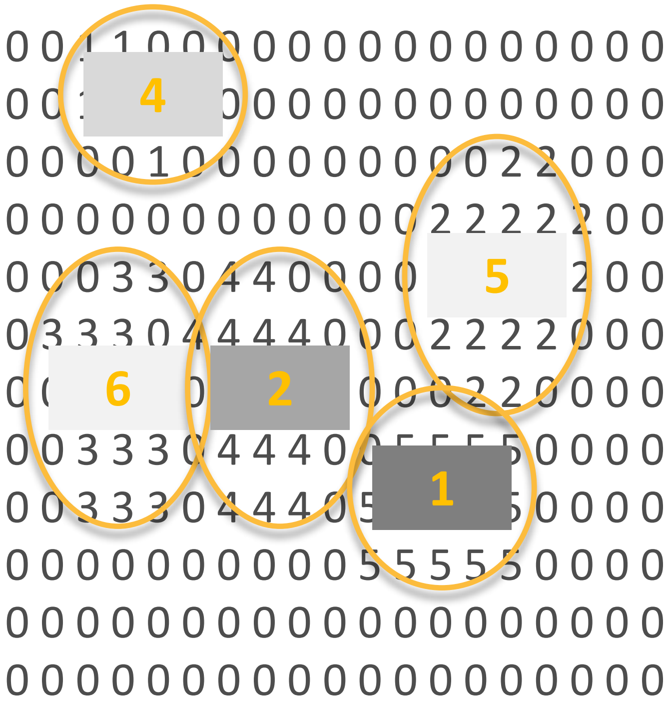
```
0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 1 0 0 0 0 0 0 0 0 0 2 2 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 2 2 2 2 2 0 0
0 0 0 3 3 0 4 4 0 0 0 0 2 2 2 2 2 0 0
0 3 3 3 0 4 4 4 4 0 0 0 2 2 2 2 0 0 0
0 0 3 3 0 0 4 4 4 0 0 0 0 2 2 0 0 0 0
0 0 3 3 3 0 4 4 4 0 0 5 5 5 5 0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

5 1 4 2 5 3 6 4 2 5 1
```

Output: 12 19 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 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 0 1 1 0 0 0 0 0 0 0 0 0 0 0
0 1 1 1 0 1 1 1 1 0 0 0 0 0 0 0 0 0 0
0 0 1 1 0 0 1 1 1 0 0 0 0 0 0 0 0 0 0
0 0 1 1 1 0 1 1 1 0 0 0 0 0 0 0 0 0 0
0 0 1 1 1 0 1 1 1 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 0 0 0 0 0 0 0 0 0
```

Advanced Example (continued)

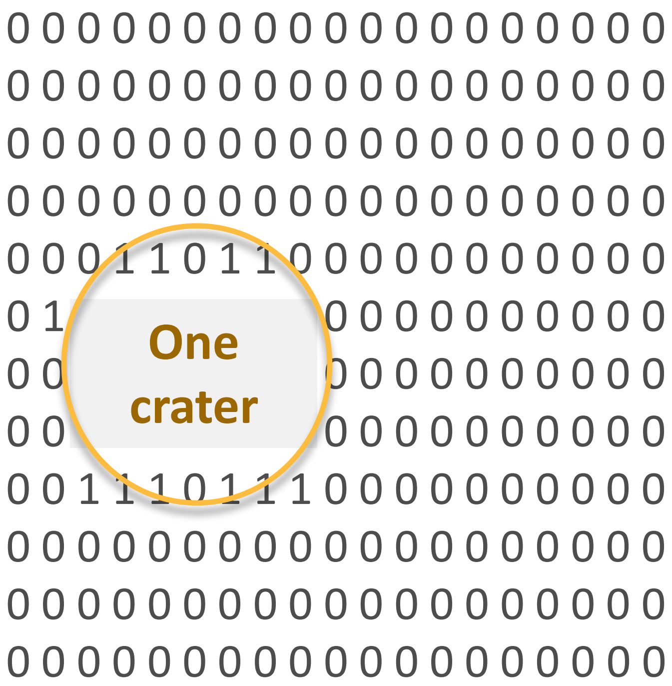
Input: 12 19 0 0 0 0 ...



```
0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 1   4   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 2 2 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 2 2 2 2 2 0 0
0 0 0 3 3 0 4 4 0 0 0 0   5     2 0 0
0 3 3 3 0 4 4 4 4 0 0 0 2 2 2 2 0 0 0
0 0   6   0   2     0 0 0 2 2 0 0 0 0
0 0 3 3 3 0 4 4 4 0 0 5 5 5 5 0 0 0 0
0 0 3 3 3 0 4 4 4 0 5   1   5 0 0 0 0
0 0 0 0 0 0 0 0 0 0 5 5 5 5 5 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
```

5 1 4 2 5 3 6 4 2 5 1

Output: 12 19 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 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 0 1 1 0 0 0 0 0 0 0 0 0 0 0
0 1       One     0 0 0 0 0 0 0 0 0 0
0 0               0 0 0 0 0 0 0 0 0 0
0 0     crater    0 0 0 0 0 0 0 0 0 0
0 0 1 1 1 0 1 1 1 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 0 0 0 0 0 0 0 0 0
```