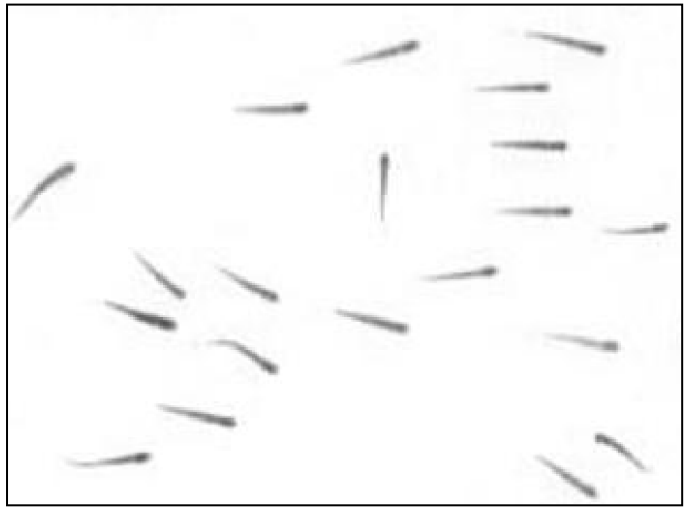
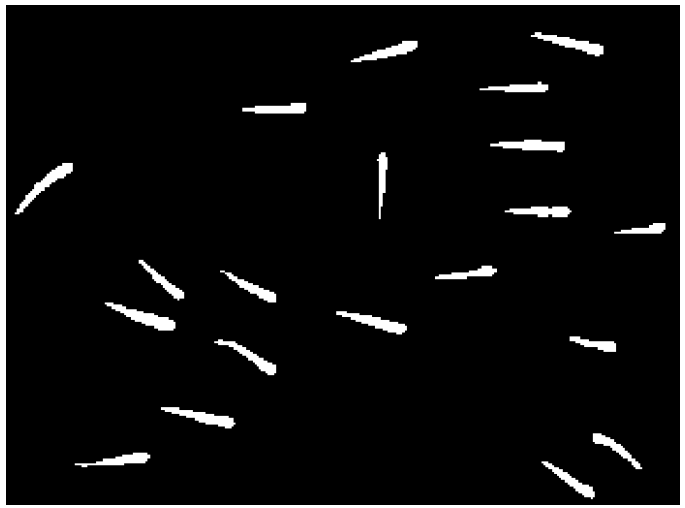
Region labeling and counting

- How many fish in this picture?



Original *Fish* image



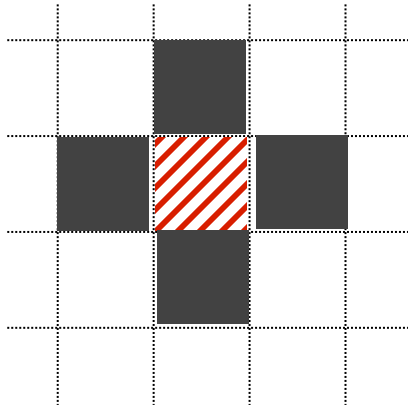
after thresholding

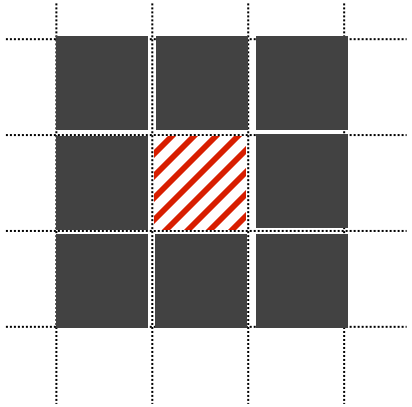
- Which pixels belong to the same object (region labeling)?
- How large is each object (region counting)?

4-connected and 8-connected neighborhoods

- Definition: a ***region*** is a set of pixels, where each pixel can be reached from any other pixel in the region by a finite number of steps, with each step starting at a pixel and ending in the neighborhood of the pixel.

4-neighborhood



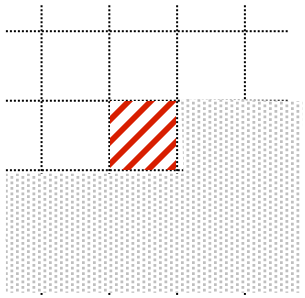


8-neighborhood

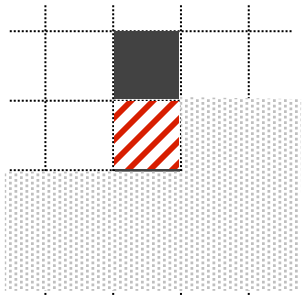
- Typically, either definition leads to the same regions, except when a region is only connected across diagonally adjacent pixels.

Region labeling algorithm (4-neighborhood)

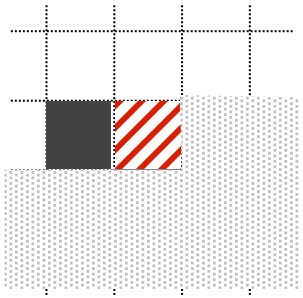
- Loop through all pixels $f[x,y]$, left to right, top to bottom
- If $f[x,y]=0$, do nothing.
- If $f[x,y]=1$, distinguish 4 cases



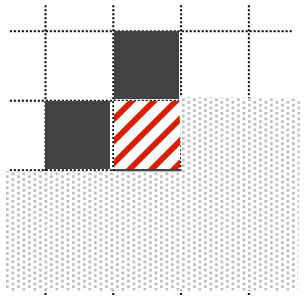
Generate new region label



Copy label from above



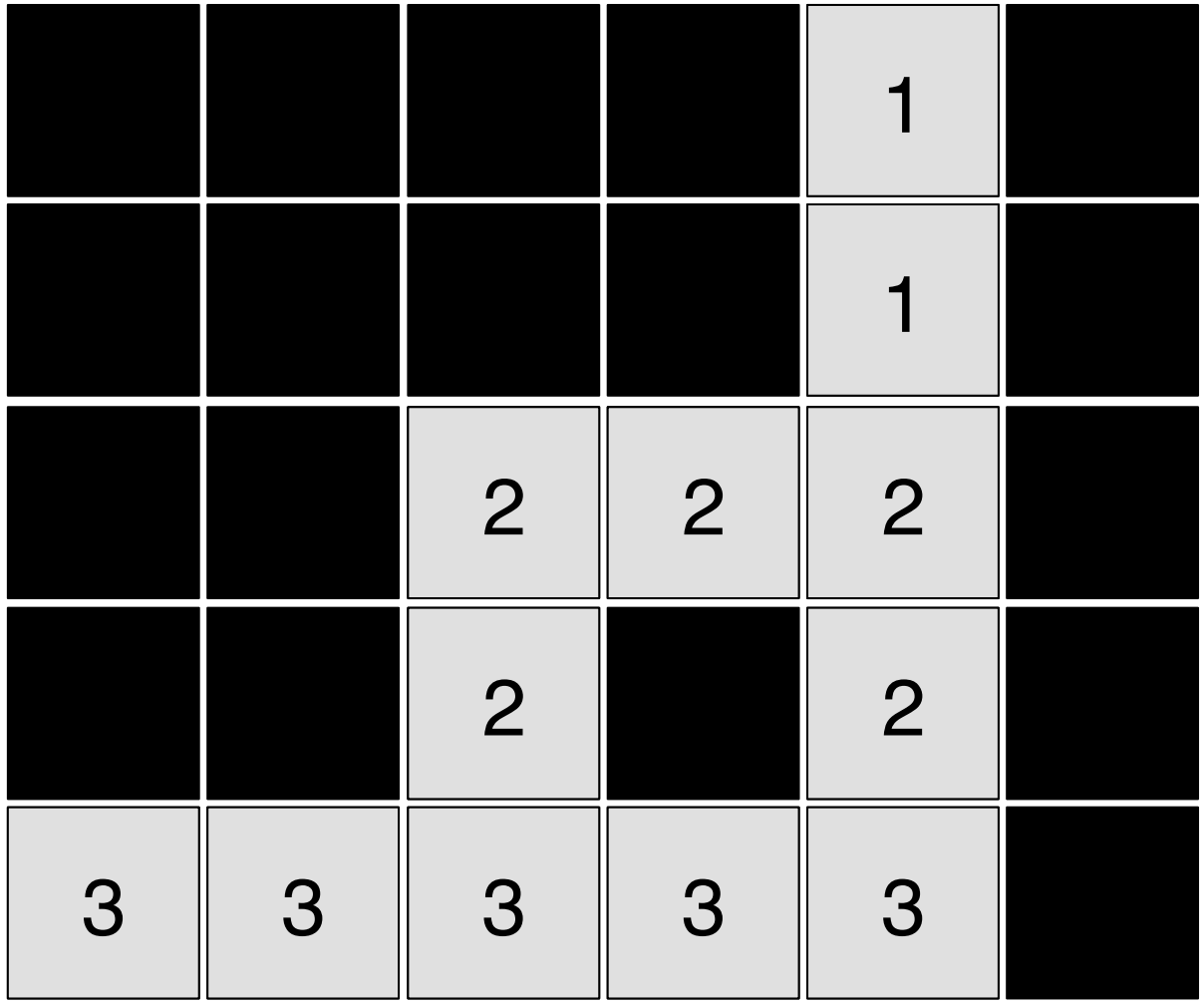
Copy label from the left



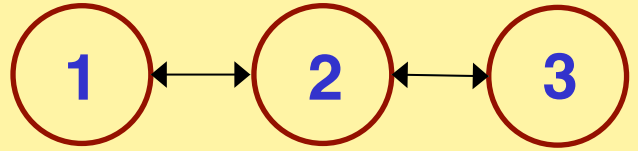
Copy label from the left. If labels above and to the left are different, store equivalence.

- Second pass through image to replace equivalent label by the same label.

Region labeling example (4-neighborhood)

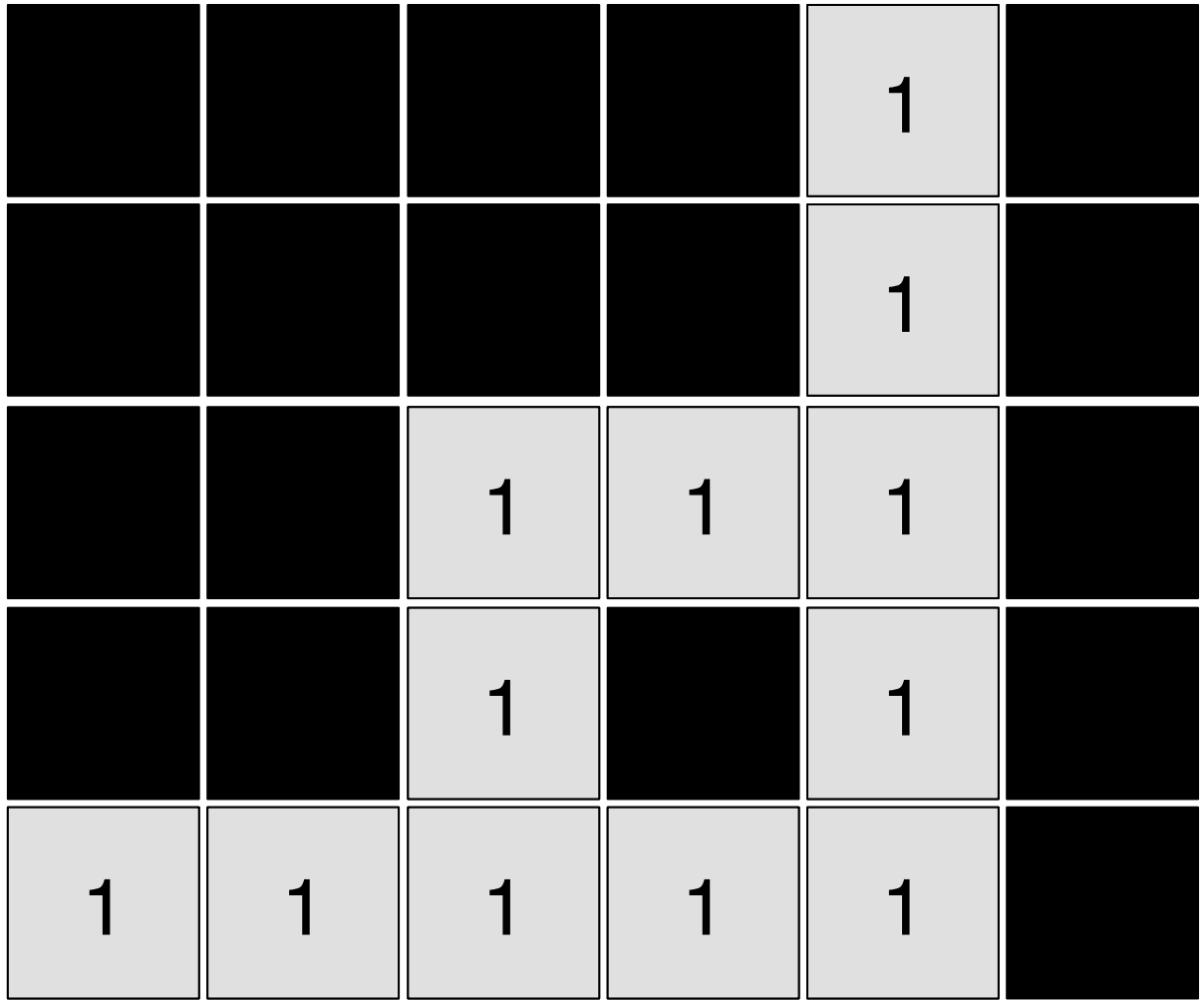


List of Region Labels



All three labels are equivalent, so merge into single label.

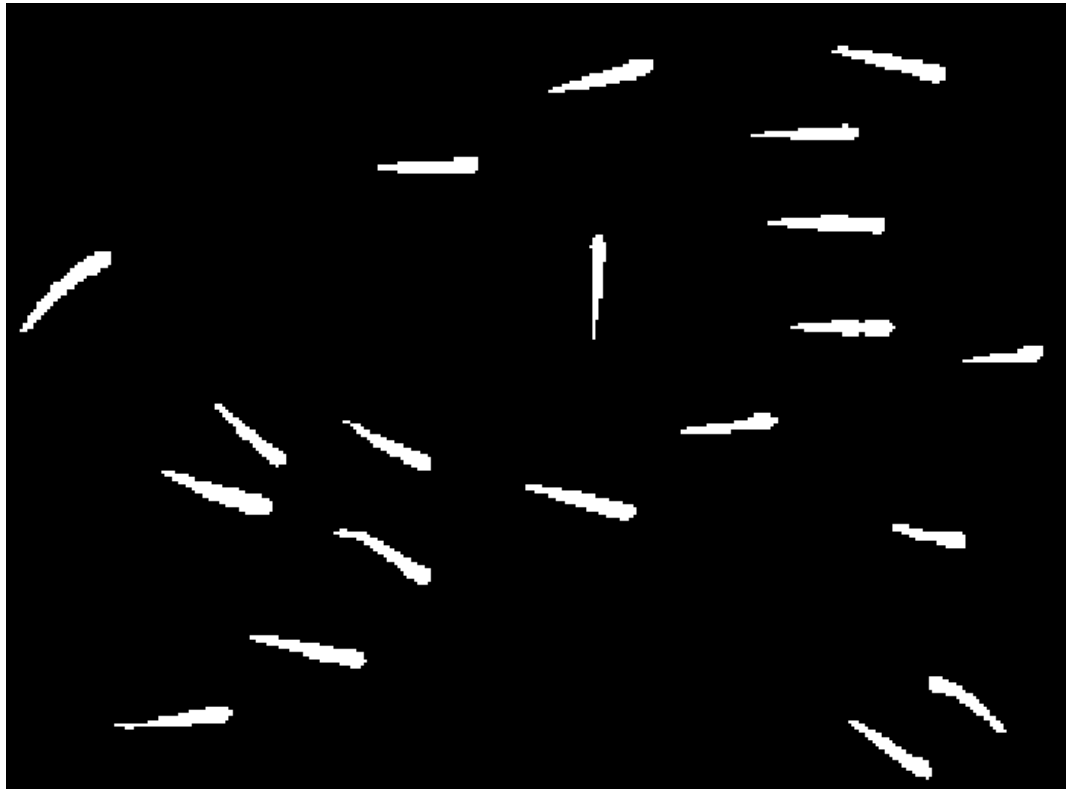
Region labeling example (4-neighborhood)



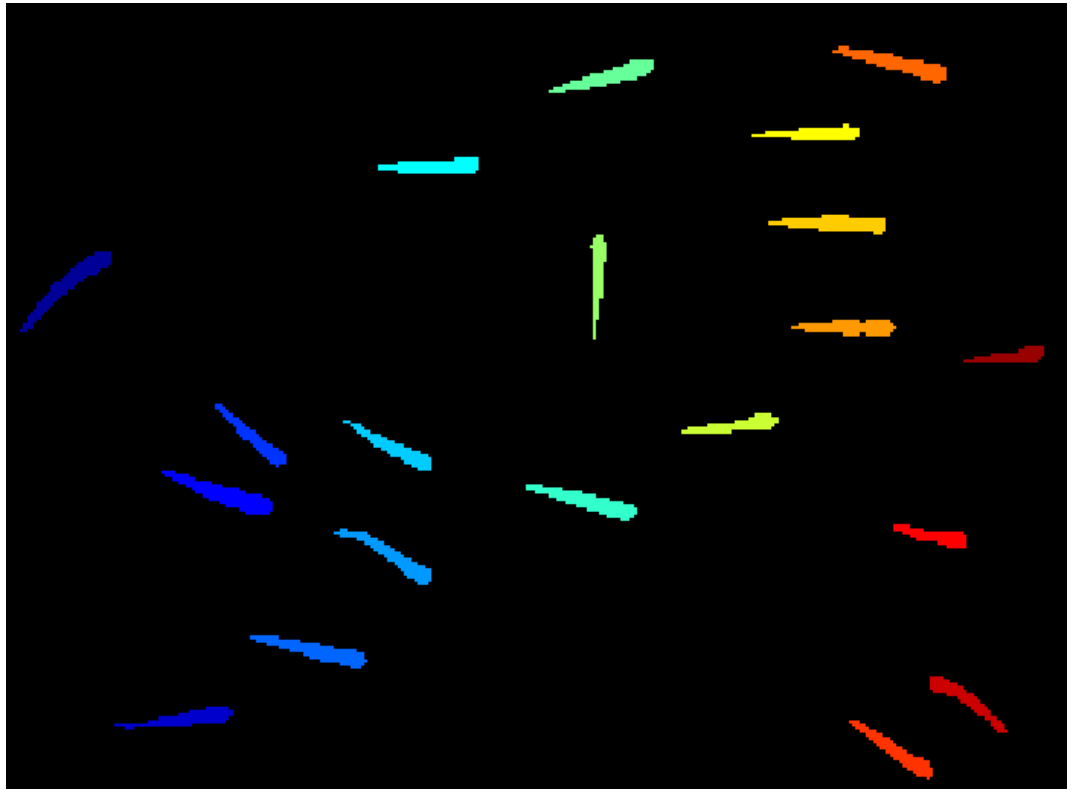
List of Region Labels

1

Example: region labeling



Thresholded image



20 labeled regions

Region counting algorithm

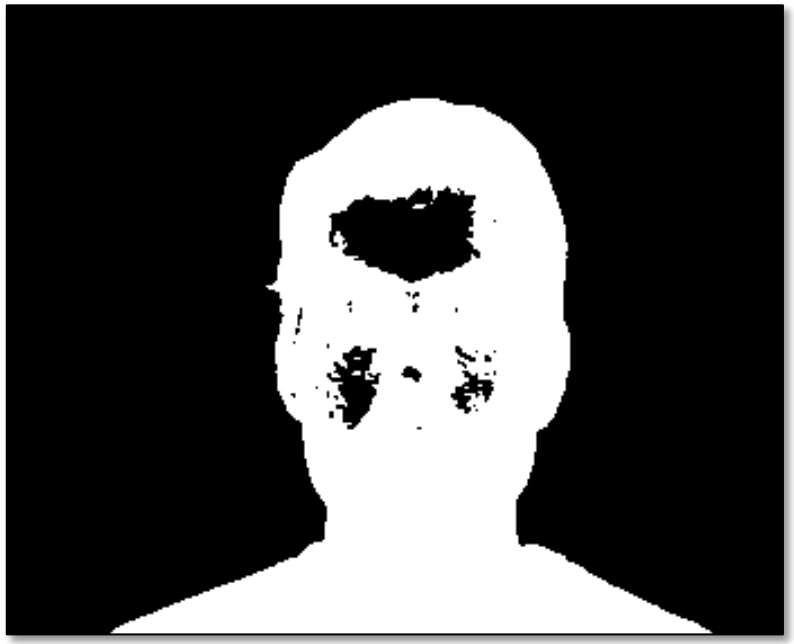
- Measures the size of each region
- Initialize $counter[label]=0$ for all $label$
- Loop through all pixels $f[x,y]$, left to right, top to bottom
  - If $f[x,y]=0$, do nothing.
  - If $f[x,y]=1$, increment $counter[label[x,y]]$

Small region removal

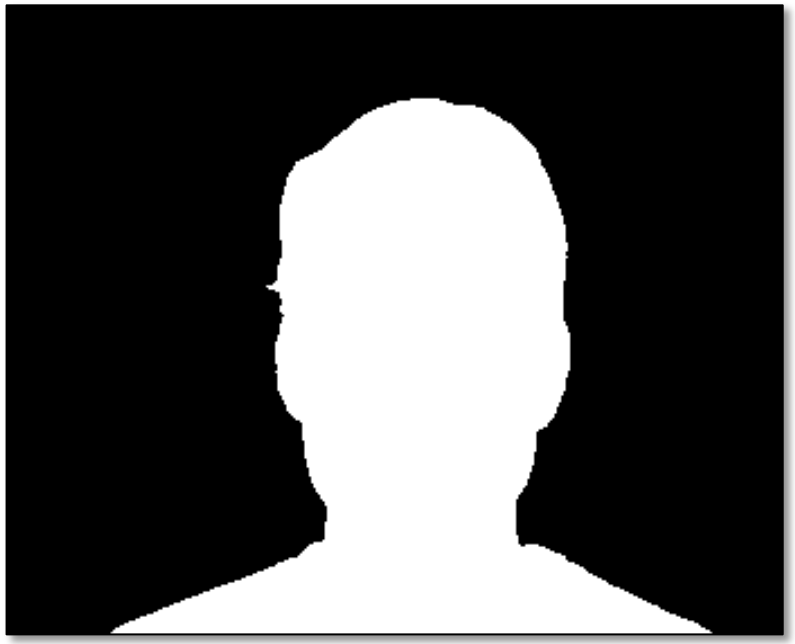
- Loop through all pixels $f[x,y]$, left to right, top to bottom
  - If $f[x,y]=0$, do nothing.
  - If $f[x,y]=1$ and $counter[label[x,y]]<S$, set $f[x,y]=0$
- Removes all regions smaller than S pixels

Hole filling as dual to small region removal

Mask with holes



After NOT operation, (background) region labeling, small region removal, and second NOT operation

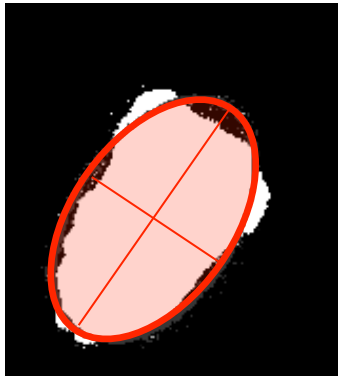


Region moments

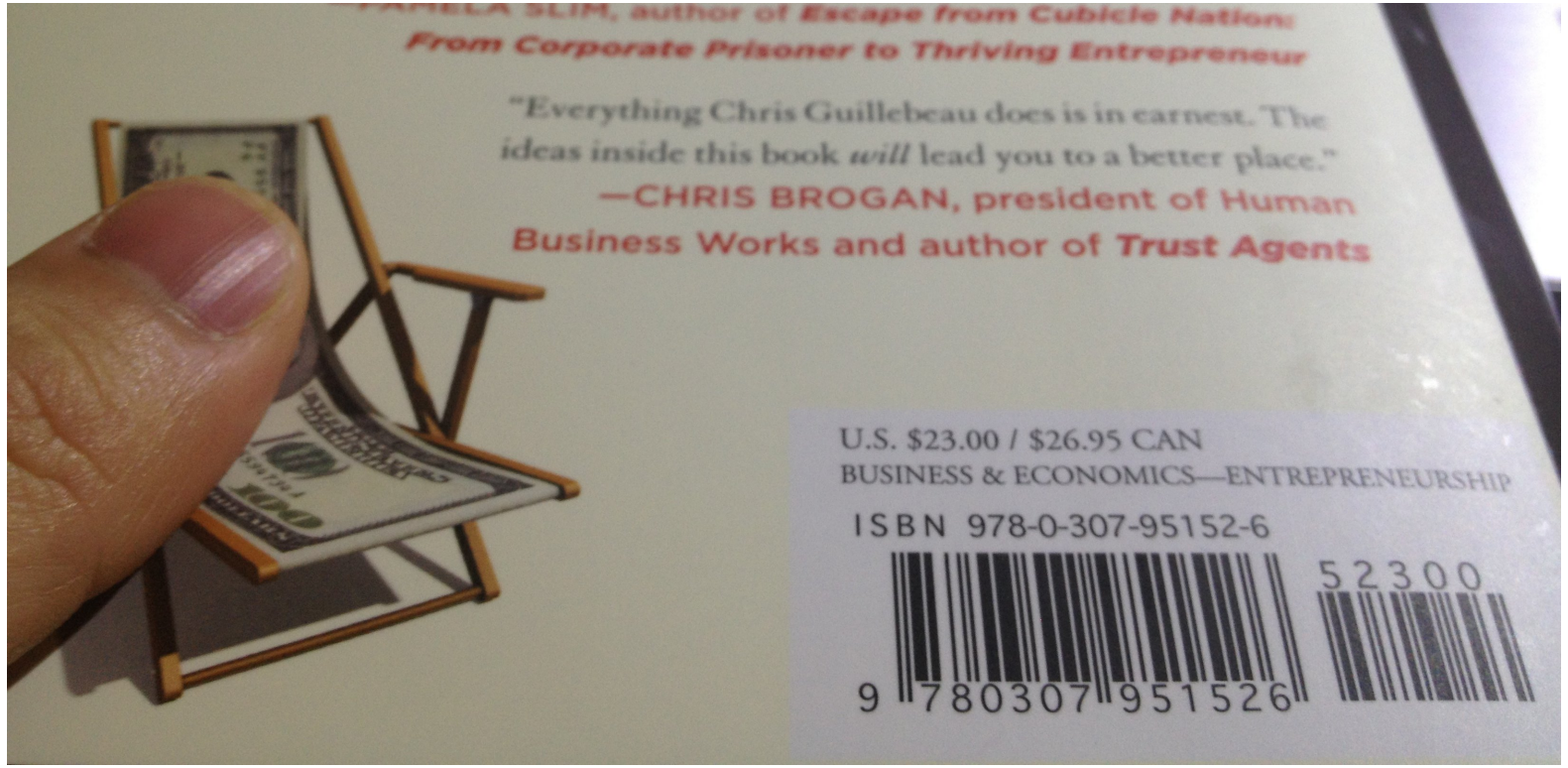
- Raw moments $$M_{pq} = \sum_{x,y \in \text{Region}} x^p y^q$$
- Central moments

$$\mu_{pq} = \sum_{x,y \in \text{Region}} (x - \bar{x})^p (y - \bar{y})^q \quad \text{with} \quad \bar{x} = \frac{M_{10}}{M_{00}} \quad \text{and} \quad \bar{y} = \frac{M_{01}}{M_{00}}$$

- Region orientation and eccentricity: calculate eigenvectors of covariance matrix $$\begin{bmatrix} \mu_{20} & \mu_{11} \\ \mu_{11} & \mu_{02} \end{bmatrix}$$



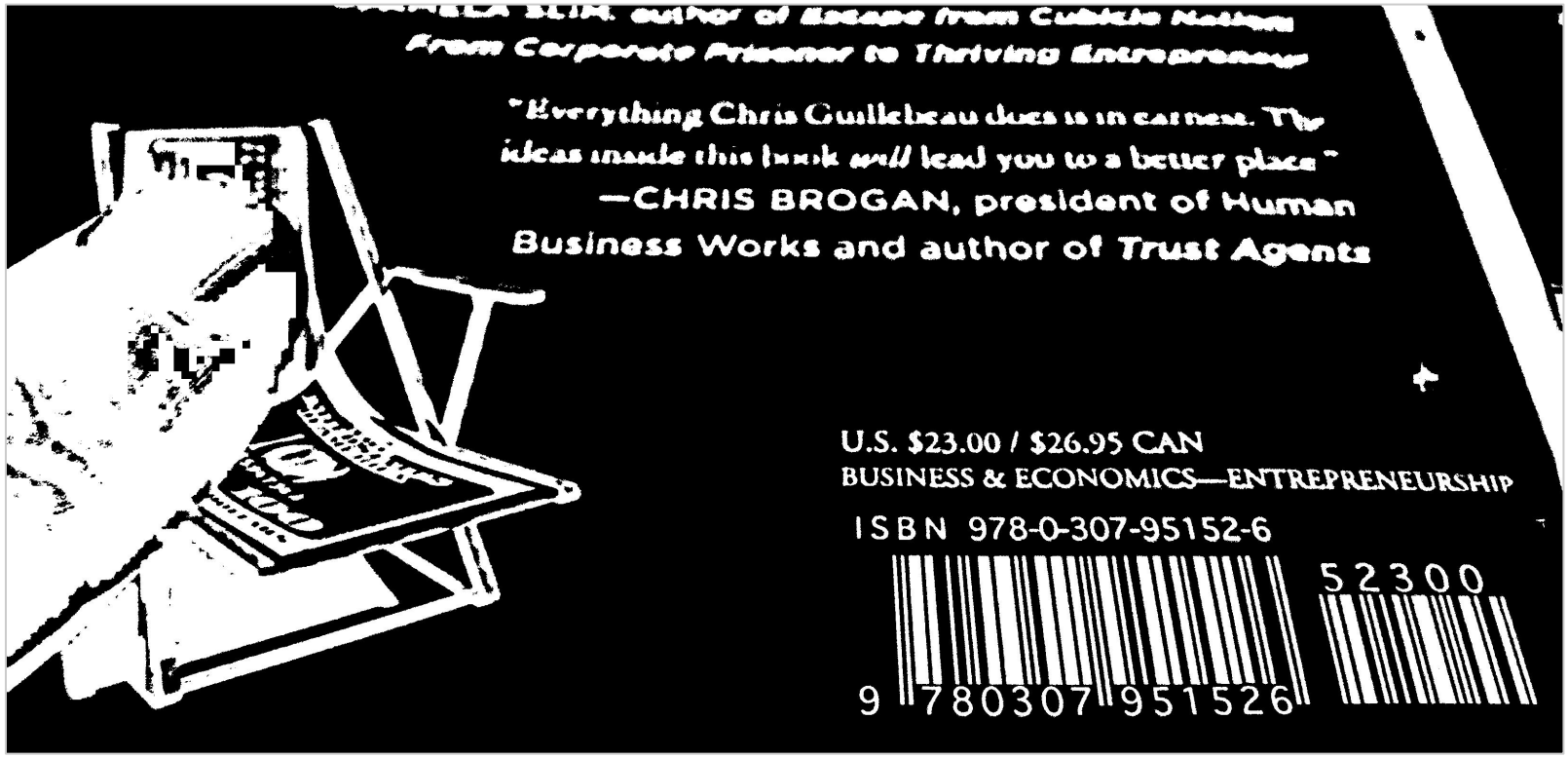
Example: Detecting bar codes



Original Image

Example: Detecting bar codes

Locally adaptive thresholding



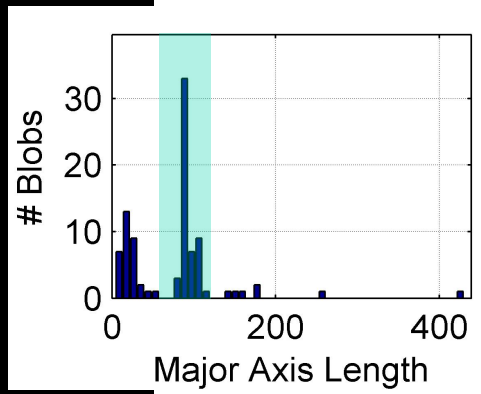
Example: Detecting bar codes

Locally adaptive thresholding

Filtering by eccentricity

Example: Detecting bar codes

- Locally adaptive thresholding
- Filtering by eccentricity
- Filtering by major axis length



Example: Detecting bar codes

- Locally adaptive thresholding
- Filtering by eccentricity
- Filtering by major axis length
- Filtering by orientation