

Lecture notes: Region properties

Once an image is segmented, we can compute properties of the individual regions. For example, imagine a machine vision system taking pictures of fruit on a conveyor so that they can be sorted by type:

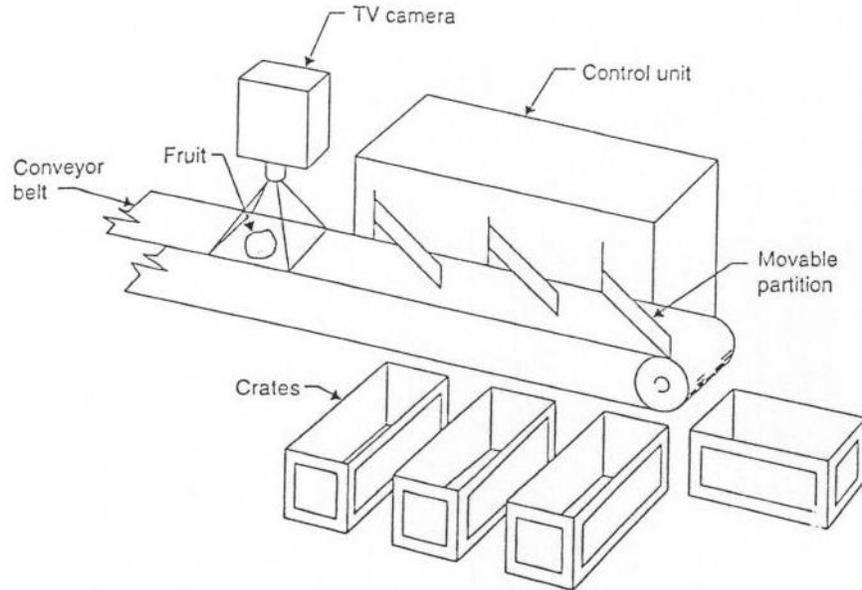


Figure 18-2 The fruit sorting system

We can compute the "redness" vs. "diameter" of the segmented areas in each image, and use these features to classify the regions (and hence the fruit).

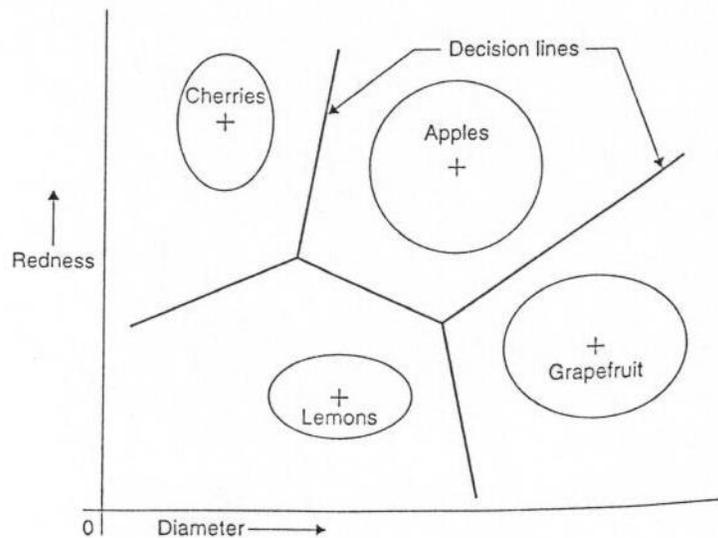


Figure 18-3 The feature space

Let R be a set of pixels $[r,c]$ in an image I , and $|R|$ be the number of pixels in the set. Here are some properties:

1. Average intensity (can also be average RGB values separately)

$$\mu = \frac{\sum_{r,c} I[r,c] \in R}{|R|}$$

Utility example: apples are red, oranges are orange.

2. Variance in intensity (also RGB separately)

$$\sigma^2 = \frac{\sum_{r,c} ((I[r,c] \in R) - \mu)^2}{|R| - 1}$$

Utility example: oranges should be orange all over (blemishes usually mean bad fruit).

3. Area

$$A = \sum_{r,c} [r,c] \in R = |R|$$

Utility example: apples are bigger than cherries.

4. Centroid

$$(\bar{r}, \bar{c}) = \left(\frac{\left(\sum_r [r] \in R \right)}{|R|}, \frac{\left(\sum_c [c] \in R \right)}{|R|} \right)$$

Utility example: where is it on the conveyor?

To compute, consider the following example image:

X					
X	X				
X	X	X			

The centroid is $(1+2+2+3+3+3)/6$, $(0+0+1+0+1+2)/6 = (2.3, 0.6)$.

5. Moments

The (j,k) general moment of a two-variable function $f(x,y)$ is

$$\mu_{jk} = \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} x^j y^k f(x,y) dx dy$$

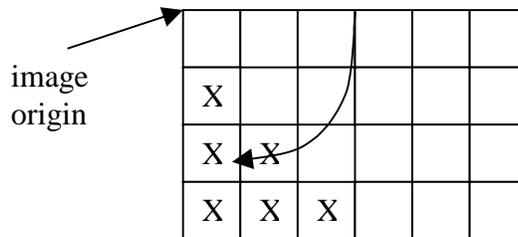
In physical terms the general moments can be used to describe dynamic properties, such as rotational forces.

In we let $f(x,y)$ be the image pixel values (binary or greyscale), and (x,y) be (column,row), we can use the general moments to describe rotational properties of regions.

For example, the rotation (theta) of a set of pixels can be found as

$$\theta = \frac{1}{2} \tan^{-1} \frac{2\mu_{11}}{\mu_{20} - \mu_{02}}$$

This describes how much a set of pixels is rotated about the origin of the image.



We can also use the moments to denote area and the centroid:

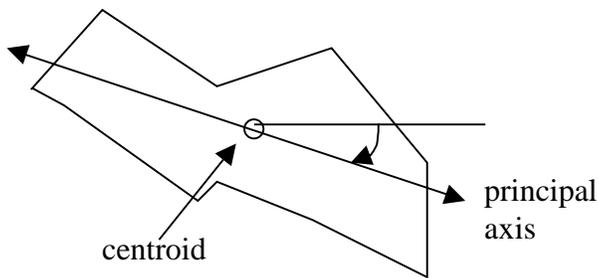
$$area = \mu_{00}$$

$$centroid = (\bar{x}, \bar{y}) = \left(\frac{\mu_{10}}{\mu_{00}}, \frac{\mu_{01}}{\mu_{00}} \right)$$

The (j,k) central moment of a two-variable function $f(x,y)$ is

$$\mu_{jk} = \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} (x - \bar{x})^j (y - \bar{y})^k f(x,y) dx dy$$

The central moments describe the dynamics about the center of mass of the shape. For example, the above formula for rotation now provides the rotation of the principal axis (direction of densest mass) of the shape:



Utility example: how is the apple oriented on the conveyor?

6. Perimeter

$$P = \sum_{r,c} [([r,c] \in R) \text{ AND } (([r \pm 1, c \pm 1] \cap R) \neq \phi)]$$

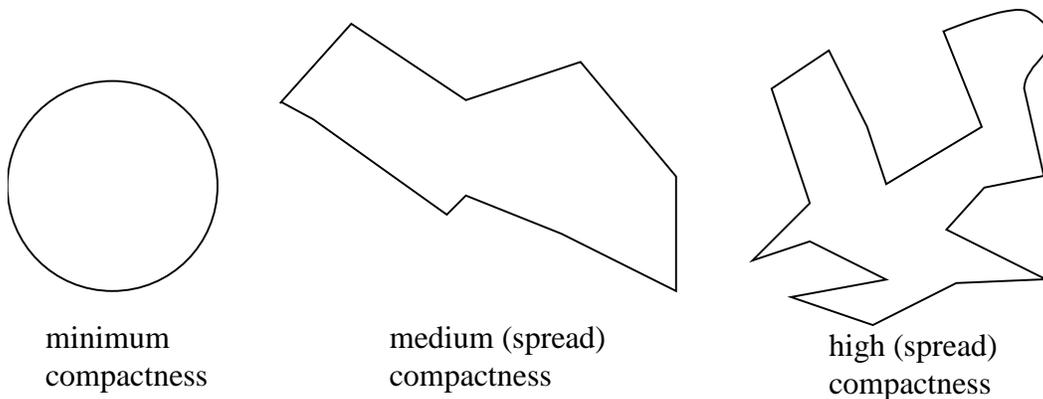
This complicated function says a pixel is on the perimeter of a region if it is in the region AND at least one of its 8-neighbors (or 4-neighbors) is not in the region. P is the count of perimeter pixels.

Utility example: where is the boundary of that apple?

7. Compactness

$$\text{Compactness} = \frac{P^2}{A} = \frac{\text{perimeter}^2}{\text{area}}$$

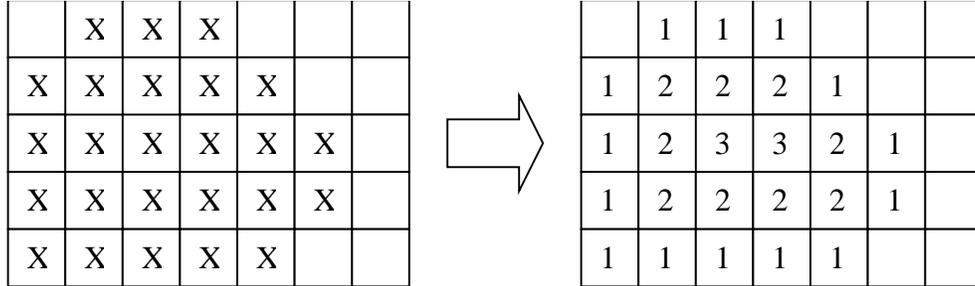
What is compactness? A circle has perimeter $2\pi r$ and area πr^2 so that its compactness is 4π . This is the minimum compactness. The larger the compactness gets, the more "spread out" the shape. For example:



Utility example: fruit should not be squashed.

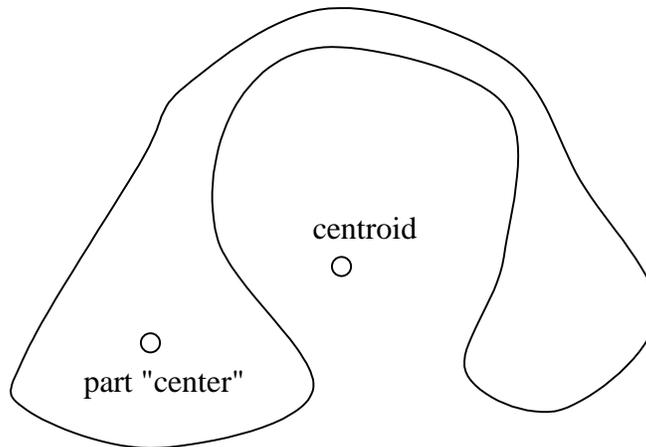
8. Chamfer distance

Technically speaking, the Chamfer distance is not a region property, it is a property of the pixels in the region. But you have to have a region in order to define it. It is the distance of each pixel in the region to the boundary of the shape:



How is it computed? It can be done by successively peeling the perimeter, and also by paint-fill type techniques.

It can be used to find the "center" of the "biggest part" of a shape, when the centroid is useless. For example:



It can be useful for watershed thresholding.

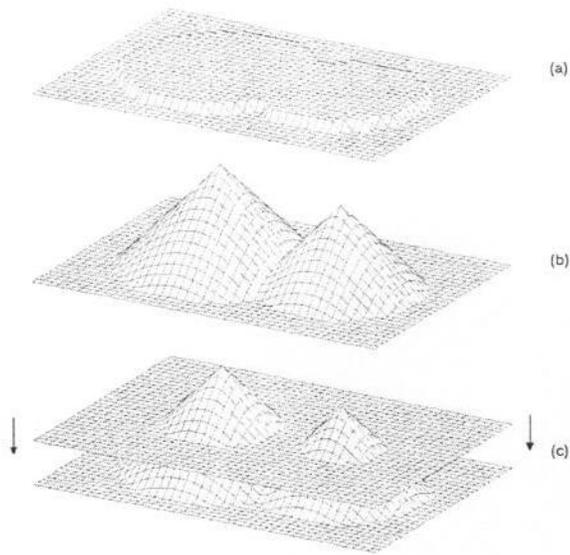


Figure 18-28 Using the watershed algorithm with the distance transform to segment touching objects: (a) binary image; (b) distance transform; (c) watershed threshold

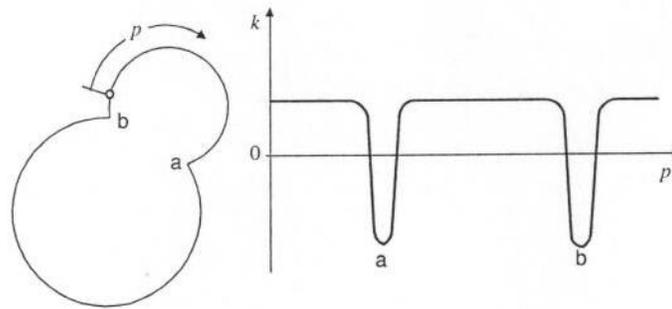


Figure 18-29 The boundary curvature function