

# Digital Image Processing

Image Segmentation:  
Thresholding

Today we will continue to look at the problem of segmentation, this time though in terms of thresholding

In particular we will look at:

- What is thresholding?
- Simple thresholding
- Adaptive thresholding

Thresholding is usually the first step in any segmentation approach

We have talked about simple single value thresholding already

Single value thresholding can be given mathematically as follows:

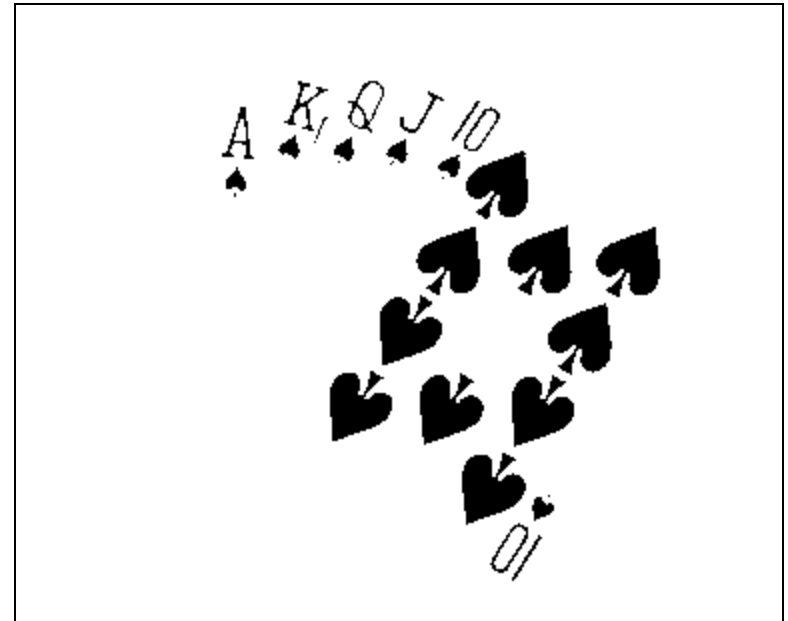
$$g(x, y) = \begin{cases} 1 & \text{if } f(x, y) > T \\ 0 & \text{if } f(x, y) \leq T \end{cases}$$

# Thresholding Example

Imagine a poker playing robot that needs to visually interpret the cards in its hand

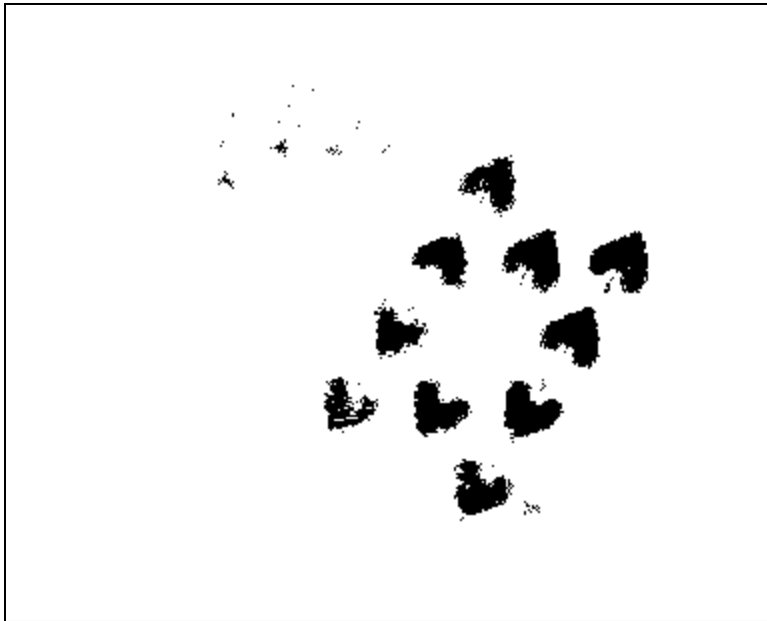


Original Image

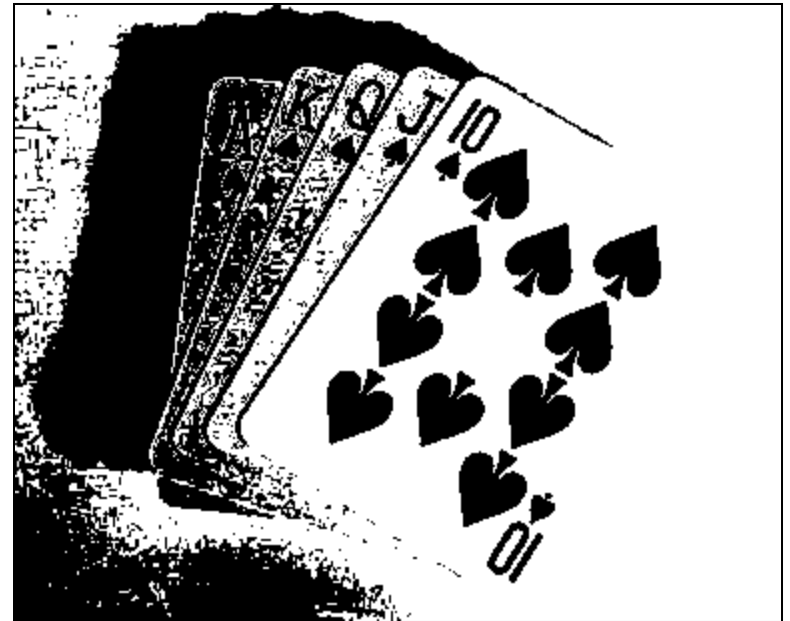


Thresholded Image

If you get the threshold wrong the results can be disastrous



Threshold Too Low



Threshold Too High

# Basic Global Thresholding

Based on the histogram of an image

Partition the image histogram using a single global threshold

The success of this technique very strongly depends on how well the histogram can be partitioned

# Basic Global Thresholding Algorithm

The basic global threshold,  $T$ , is calculated as follows:

1. Select an initial estimate for  $T$  (typically the average grey level in the image)
2. Segment the image using  $T$  to produce two groups of pixels:  $G_1$  consisting of pixels with grey levels  $>T$  and  $G_2$  consisting pixels with grey levels  $\leq T$
3. Compute the average grey levels of pixels in  $G_1$  to give  $\mu_1$  and  $G_2$  to give  $\mu_2$

# Basic Global Thresholding Algorithm

4. Compute a new threshold value:

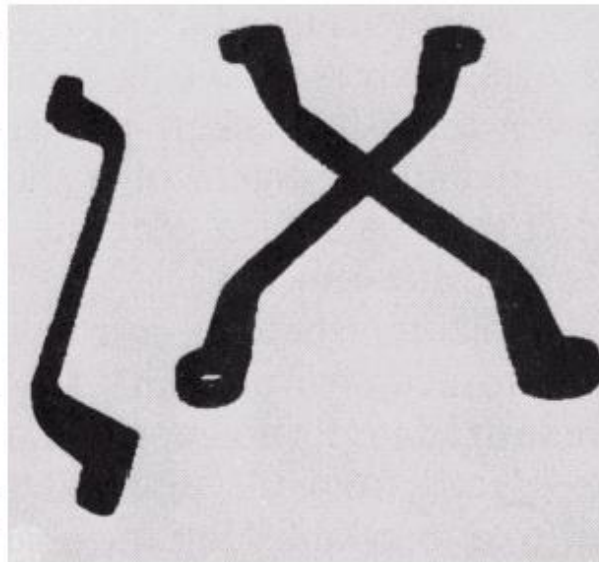
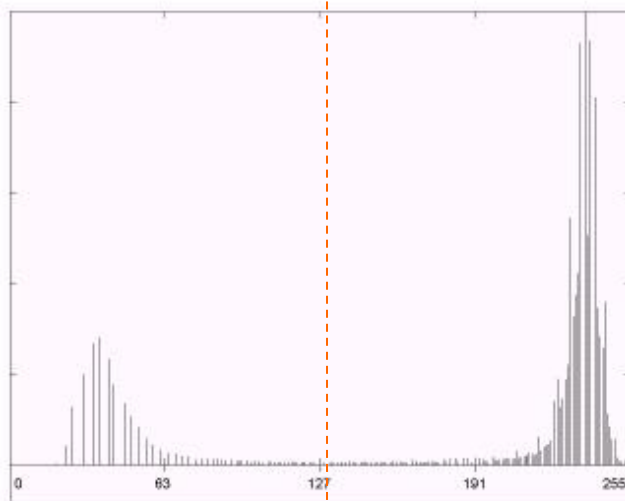
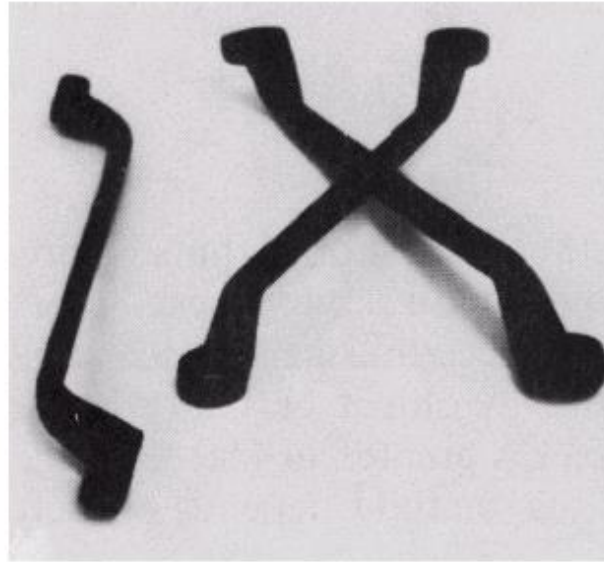
$$T = \frac{\mu_1 + \mu_2}{2}$$

5. Repeat steps 2 – 4 until the difference in  $T$  in successive iterations is less than a predefined limit  $T_\infty$

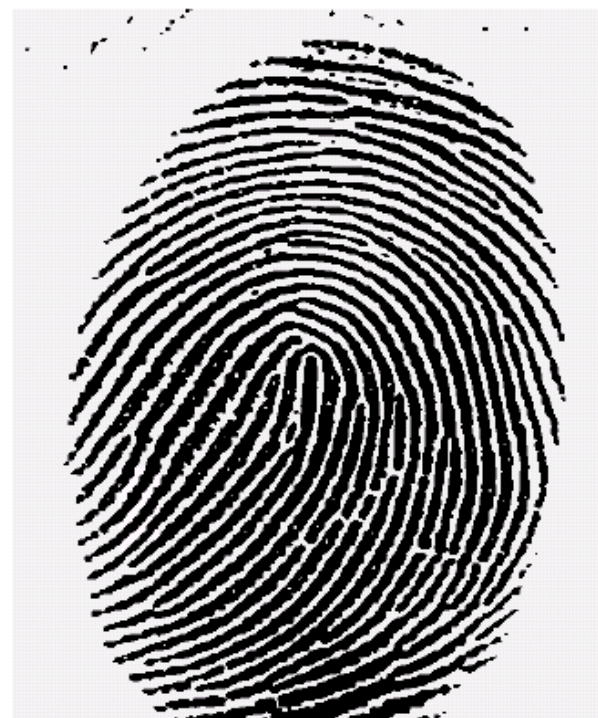
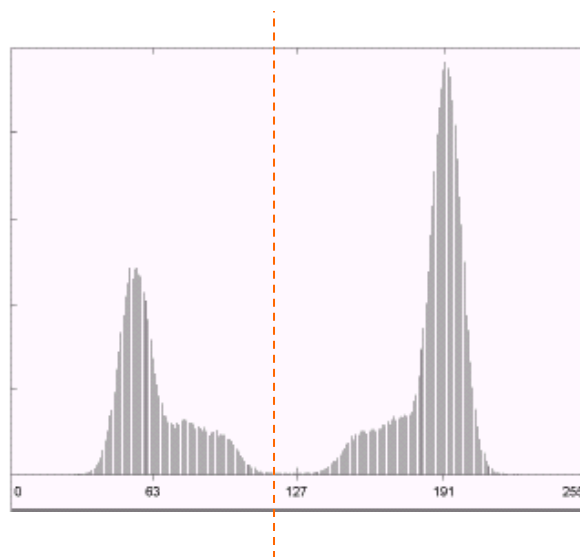
This algorithm works very well for finding thresholds when the histogram is suitable



# Thresholding Example 1



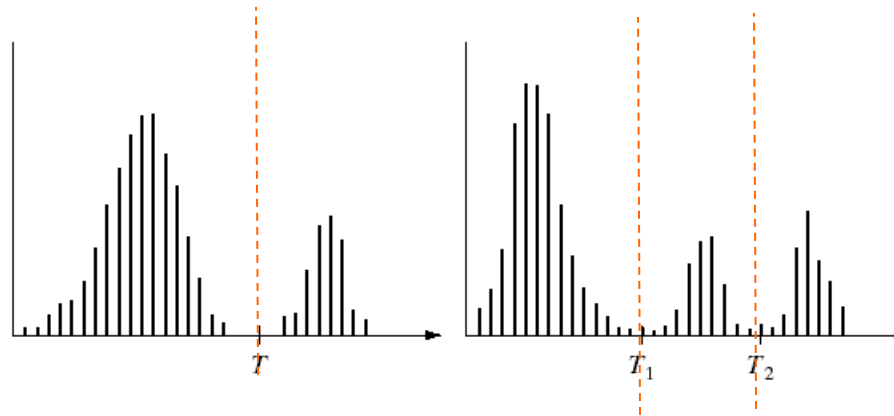
# Thresholding Example 2



# Problems With Single Value Thresholding

Single value thresholding only works for bimodal histograms

Images with other kinds of histograms need more than a single threshold

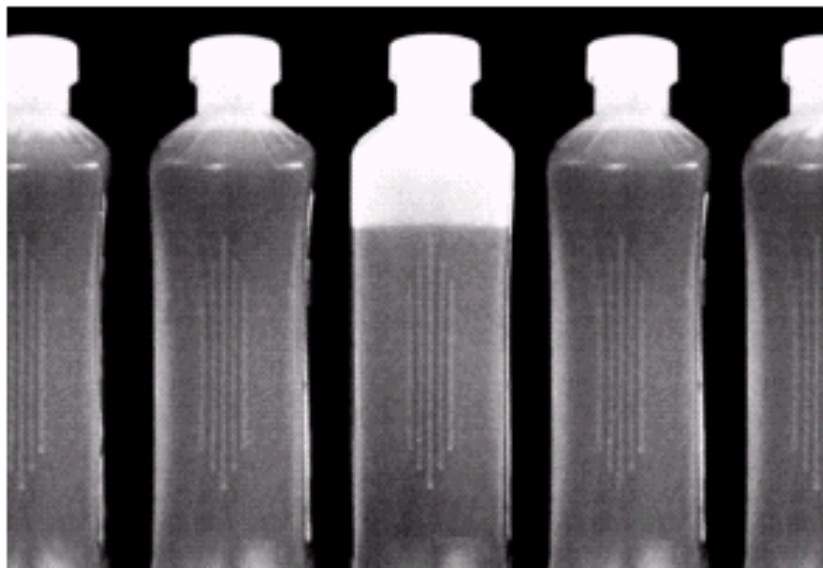


# Problems With Single Value Thresholding (cont...)

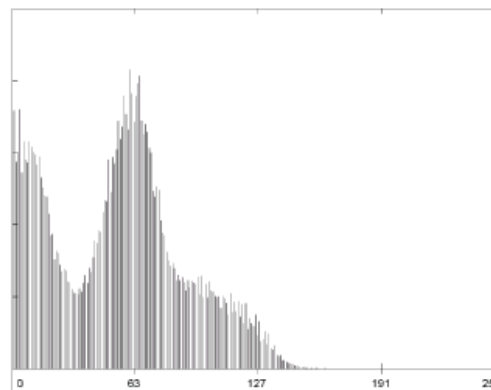
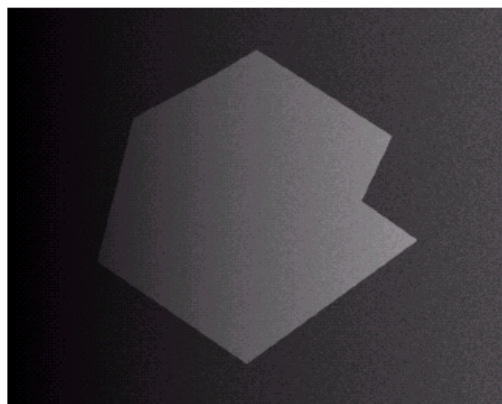
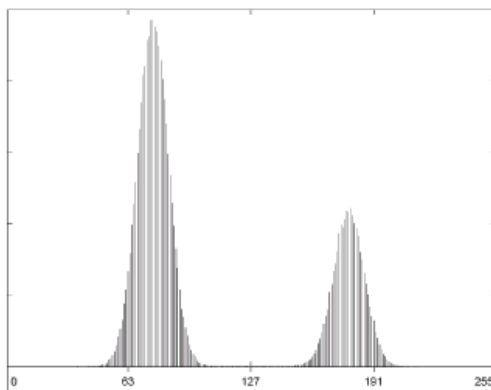
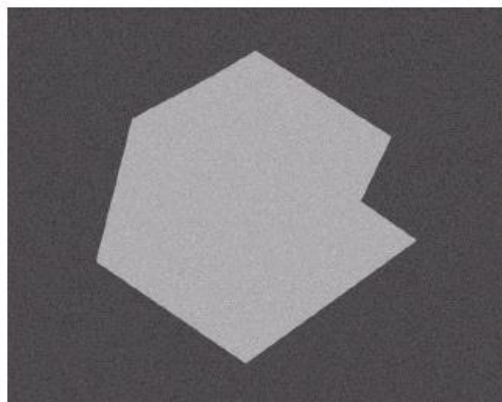
Let's say we want to isolate the contents of the bottles

Think about what the histogram for this image would look like

What would happen if we used a single threshold value?



# Single Value Thresholding and Illumination



Uneven illumination can really upset a single valued thresholding scheme

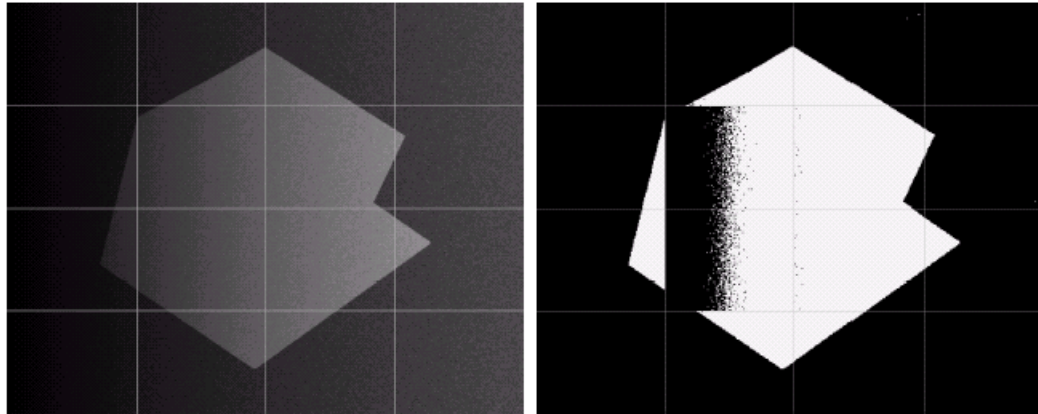
# Basic Adaptive Thresholding

An approach to handling situations in which single value thresholding will not work is to divide an image into sub images and threshold these individually

Since the threshold for each pixel depends on its location within an image this technique is said to *adaptive*

# Basic Adaptive Thresholding Example

The image below shows an example of using adaptive thresholding with the image shown previously



As can be seen success is mixed

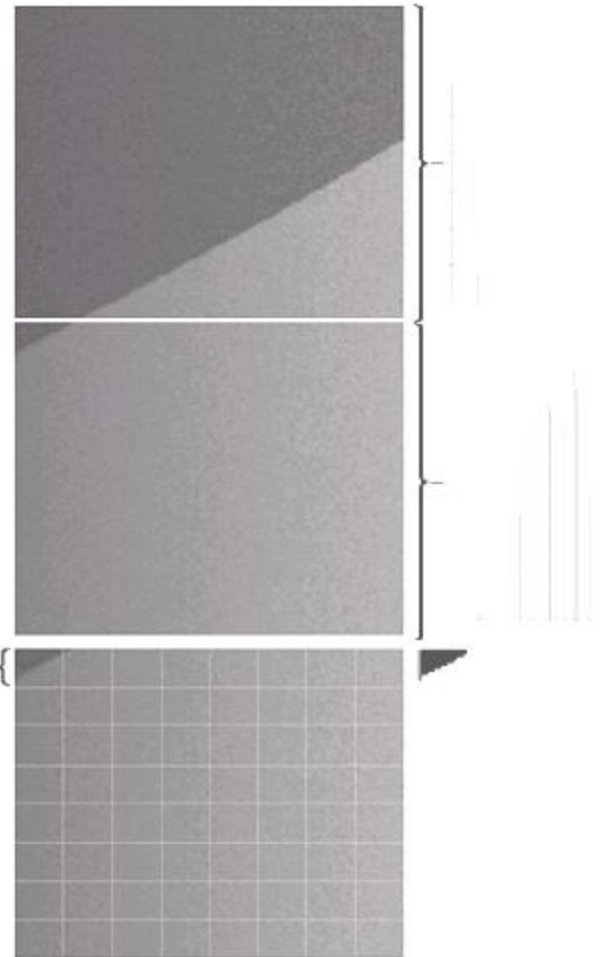
But, we can further subdivide the troublesome sub images for more success



# Basic Adaptive Thresholding Example (cont...)

These images show the troublesome parts of the previous problem further subdivided

After this sub division successful thresholding can be achieved





In this lecture we have begun looking at segmentation, and in particular thresholding

We saw the basic global thresholding algorithm and its shortcomings

We also saw a simple way to overcome some of these limitations using adaptive thresholding