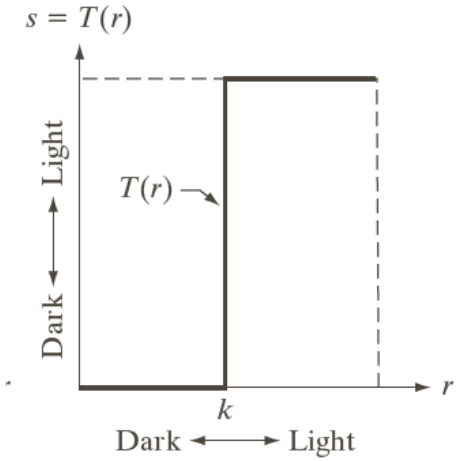
COMP2005

Thresholding & Binary Image Processing

1. What is Thresholding
2. Adaptive Thresholding

Binary Image Processing

- Many image processing operations make a decision:
  - is this the colour/object/edge I'm interested in?
- The result is a binary image
  - Pixels can have only two values: 0 or 1
  - Binary images also need noise removal, enhancement, etc.



Binarisation: Thresholding

- A dark object on a light background in a grey-level image
- Choose a threshold value, T
- Consider each pixel in turn
  - If the brightness at a pixel is less than T, that pixel is object
  - Otherwise it is part of the background
- Basic idea extends to colour; define sets of colour values that correspond to objects

Threshold, $T = 96$

Too Simple?

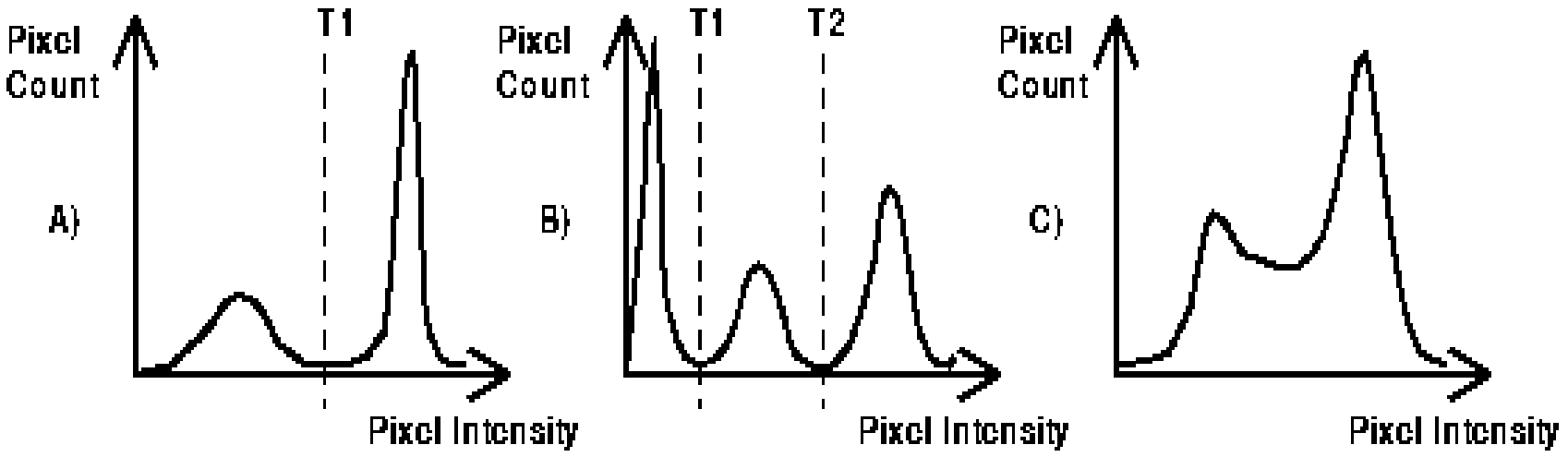
- The value of the threshold is very important
  - If it is too high, background pixels will be classified as foreground
  - If it is too low, object pixels will be considered background
- Assumes there are exactly two regions, with no overlap in their brightness – *is that true?*

$T = 128$

$T = 64$

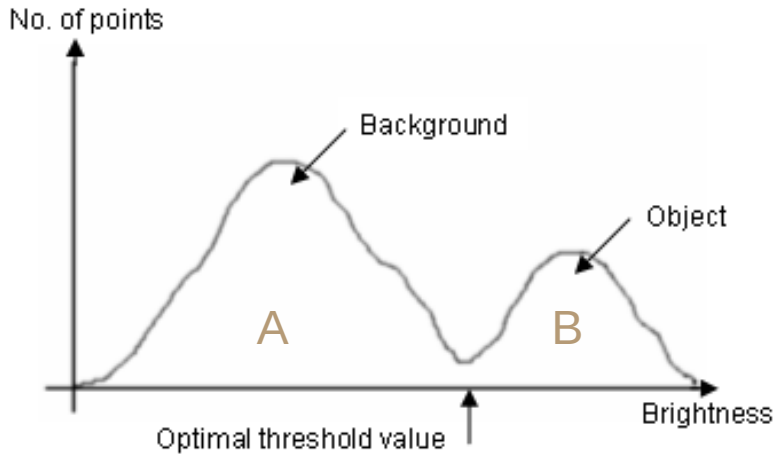
Adaptive Thresholds

- If the user chooses t for each of a set of images there is no guarantee the results will be consistent
- Automatic methods choose a threshold based on image properties: histograms are commonly used



Otsu Thresholding

- Assumes histograms are *bimodal*; two regions can be separated by one threshold
- Think of the histogram as made of two normal (Gaussian) distributions, described by their means and deviations
- If a threshold is wrong it will include histogram bins from peak A in peak B
  - Peak A's deviation will be too small
  - Peak B's deviation will be too big
  - Peak A's size (area) will be too small
  - Peak B's size will be too big



Otsu Thresholding

- Find the threshold which minimises a weighted sum of the variations of the two regions that threshold produces
  - Weights are the areas of the histogram assigned to each region

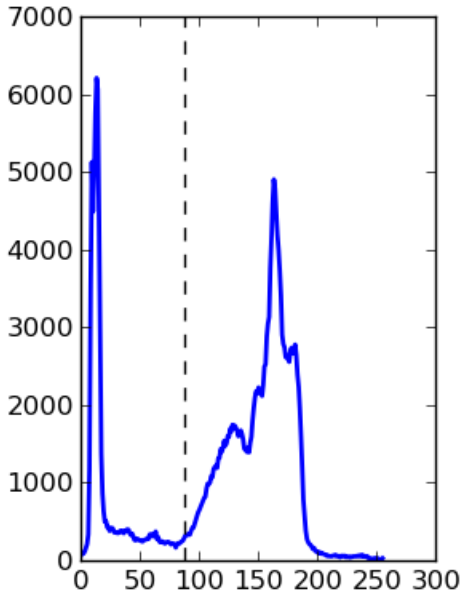
$$\sigma_w^2(t) = q_1(t)\sigma_1^2(t) + q_2(t)\sigma_2^2(t)$$

$$q_1(t) = \sum_{i=1}^{t} P(i) \qquad q_2(t) = \sum_{i=t+1}^{I} P(i)$$

- This is small when the two regions are both physically small and have low deviations

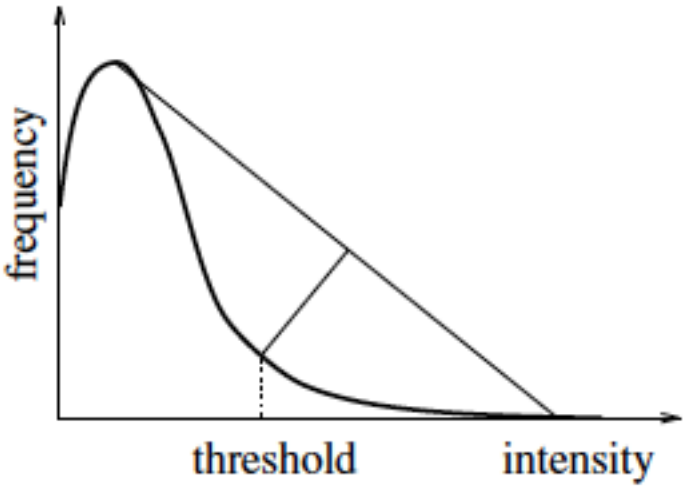
Otsu Thresholding

- The Algorithm
  - consider all possible threshold values (0 - 255)
  - compute weighted sum
  - pick t with smallest value
- A recursive version exists that is very efficient



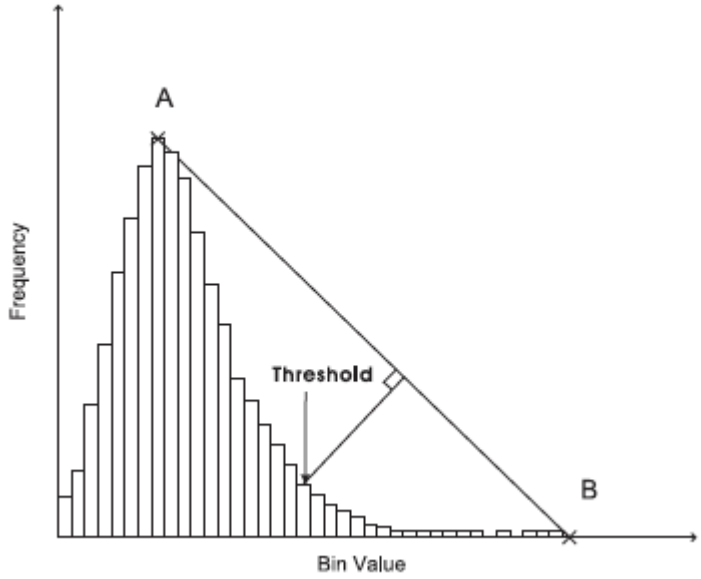
Unimodal Thresholding

- Many histograms are not bimodal, there is often only one peak e.g. text is mainly white, with a small amount of black
- Rosin's unimodal method
  - Finds the peak
  - Draws a line from there to the top of the furthest bin
  - Finds the top of the bin that is value



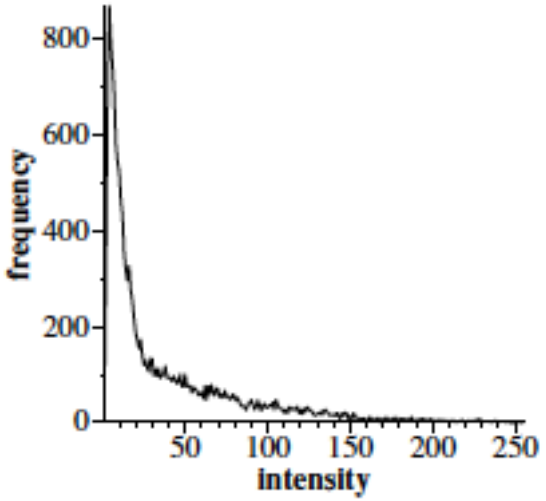
Unimodal Thresholding

- Many histograms are not bimodal, there is often only one peak e.g. text is mainly white, with a small amount of black
- Rosin's unimodal method
  - Finds the peak
  - Draws a line from there to the top of the furthest bin
  - Finds the top of the bin that
  - is furthest from this line; that bin value is the threshold
  - The threshold is selected at the point of the histogram that **maximizes** the perpendicular distance from the histogram to the straight line.



Unimodal Threshold

- Can be applied to any suitable image, e.g. intensity gradients



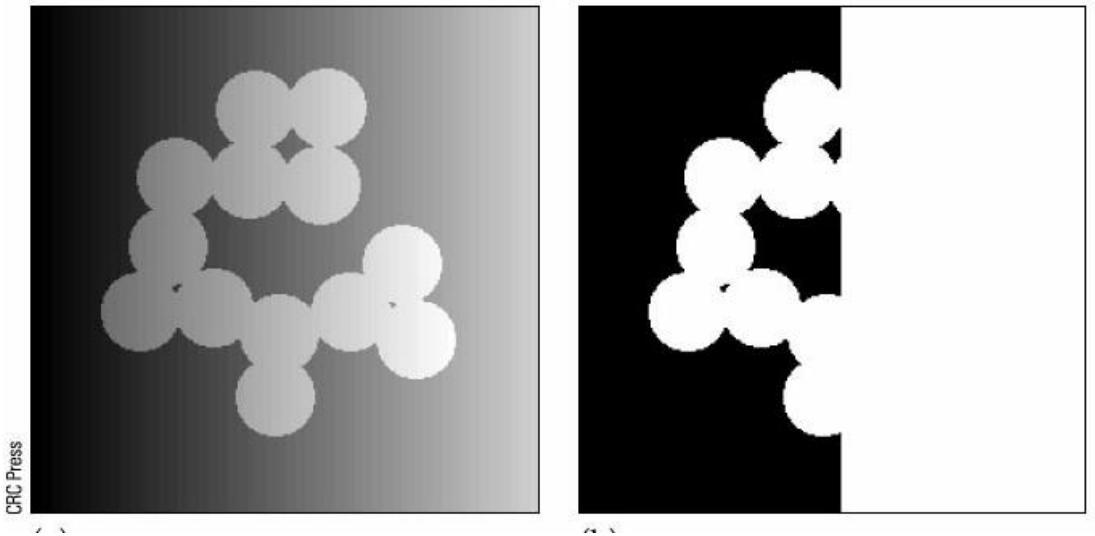
Unimodal Thresholding

- Rosin

- Otsu

Local Adaptive Methods

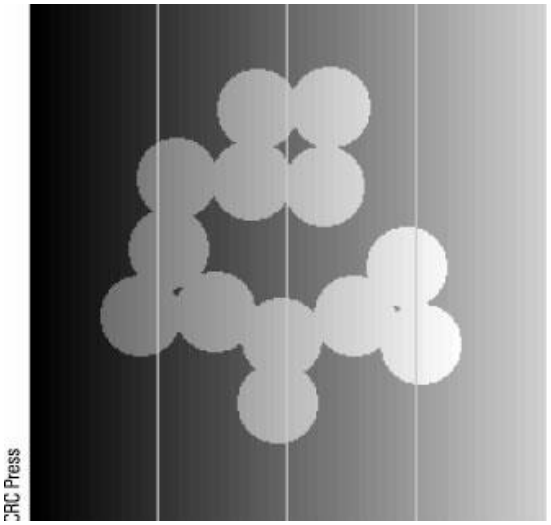
- Imaging conditions and object properties can vary within a single image as well as across sets of images
- Histograms can be too complex for any method's assumption to be true

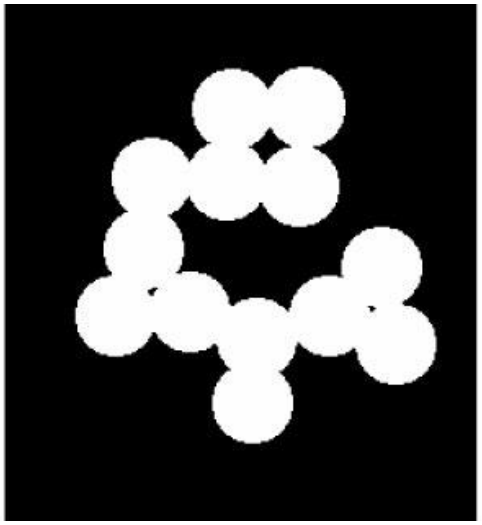


- Otsu

Local Adaptive Methods

- Assumptions about histograms may, however, be true for local areas of the image
- Divide image into subregions, apply a threshold selection method independently to each





- The histograms of each vertical strip of this image are bimodal
- Otsu can be applied to each strip

Conclusion

- Binary images contain only two values, but they are still images and can be processed
- Thresholding is the most common way to produce them
  - fixed vs adaptive
  - global vs local

Next Week

Morphological Approaches