Global Thresholding

Let f(x,y) be the source image and b(x,y) the binary image.

$$b(x,y)=\begin{cases}1, & f(x,y)\le T\\ 0, & otherwise\end{cases}$$

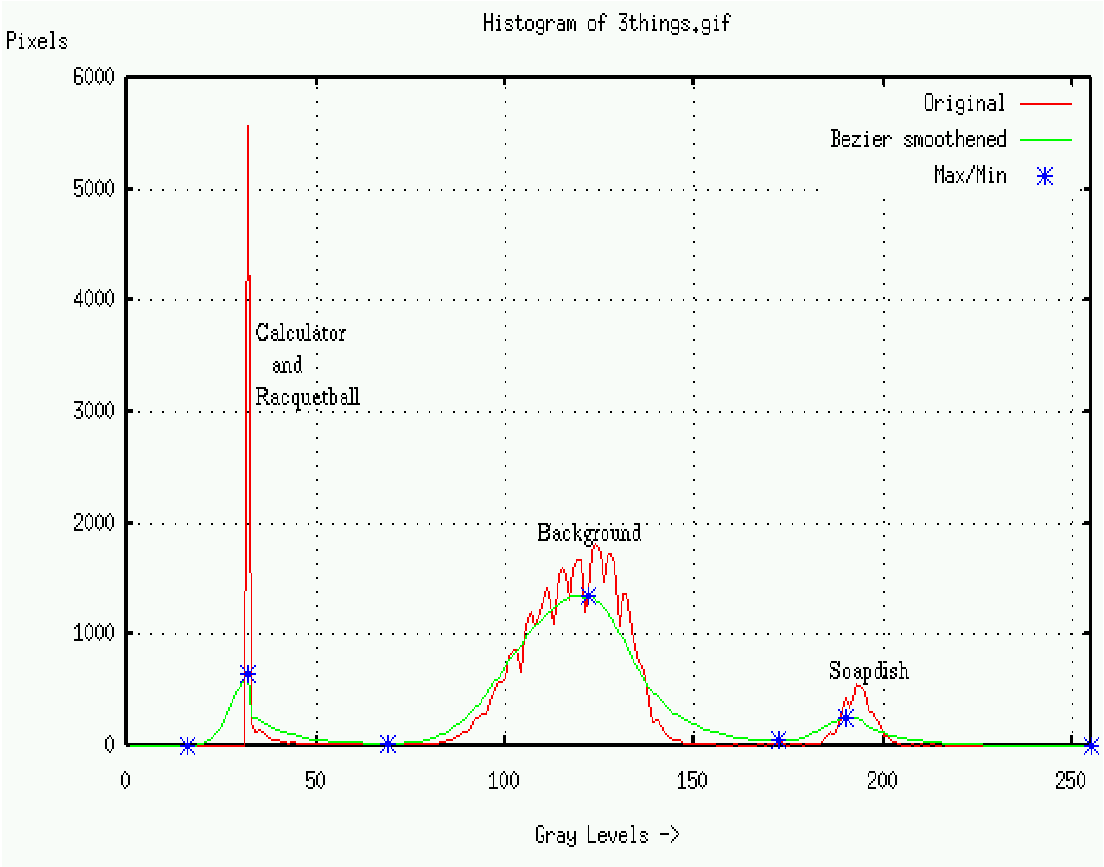
$Object \in [T_1, T_2]$

$$b(x,y)=\begin{cases}1, & T_1 \le f(x,y)\le T_2\\ 0, & otherwise\end{cases}$$

$Object \in Z$

where Z is a set of intensity values

$$b(x,y)=\begin{cases}1, & f(x,y)\in Z\\ 0, & otherwise\end{cases}$$



Histogram analysis

Semithresholding

- Pixels whose values lie within a given threshold range retain their original values. Pixels with values lying outside of the threshold range are set to 0.

$$b(x,y) = \begin{cases} f(x,y) \ if \ h \le f(x,y) \le k \\ 0 \quad otherwise \end{cases}$$

- Regions of high values can be isolated using:

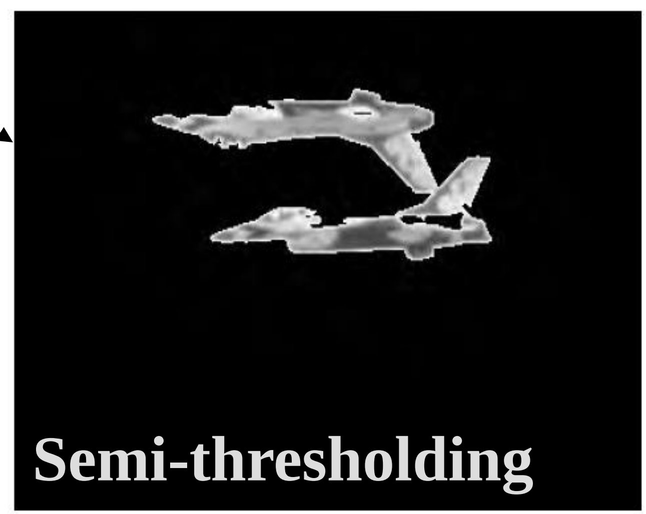
$$b(x,y) = \begin{cases} f(x,y) \ if \ f(x,y) \ge k \\ 0 \quad otherwise \end{cases}$$

- Regions of low values can be isolated using:

$$b(x,y) = \begin{cases} f(x,y) \ if \ f(x,y) \le k \\ 0 \quad otherwise \end{cases}$$

Technical University of Cluj Napoca
Computer Science Department

Example



Multilevel thresholding

- Multilevel thresholding allows for segmentation of pixels into multiple classes.
- For example, if the image histogram contains three peaks, then it is possible to segment the image using two thresholds. These thresholds divide the value set into three non-overlapping ranges, each of which can be associated with a unique value in the resulting image.
- Let f(x,y) be the source image and let $k_1, \dots, k_n$ be threshold values satisfying $k_1 > k_2 > \dots > k_n$. These values partition R into n+1 intervals which are associated with values $v_1, \dots, v_{n+1}$ in the thresholded result image.
- The threshold image b is defined by:

$$b(x,y) = \begin{cases} v_1 \ \text{if} \ f(x,y) < k_1 \\ v_i \ \text{if} \ k_{i-1} \le f(x,y) < k_i \\ v_{n+1} \ \text{if} \ k_n \le f(x,y) \end{cases}$$

Variable Thresholding

- Variable thresholding allows different threshold levels to be applied to different regions of an image.
- Let f(x,y) be the source image and let d(x,y) denote the local (region) threshold value associated with each point in the image, that is d(x,y) is the threshold value associated with the region in which point (x,y) lies.
- The thresholded image b(x,y) is defined by:

$$b(x,y) = \begin{cases} 1 \; if \;\; f(x,y) \geq d(x,y) \\ 0 \; if \;\; f(x,y) < d(x,y) \end{cases}$$

Threshold selection using mean and standard deviation

- Let f(x,y) , be an image
- The mean of f(x,y) is: $\mu = \frac{1}{mn}\sum_{i=1}^{m}\sum_{j=1}^{n} f(i,j)$
- The standard deviation of the image a is:

$$\sigma = \sqrt{\frac{1}{mn}\sum_{i=1}^{m}\sum_{j=1}^{n}[f(i,j)-\mu]^2}$$

- The threshold level T is set at: $\mathbf{T = k_1\mu + k_2\sigma}$ where the constants k_1 and k_2 are image type dependent.
- For typical low-resolution IR images $k_1 = k_2 = 1$ seems to work fairly well.
- For higher resolutions $k_1 = 1$ or $k_1 = 1.5$ and $k_2 = 2$ may yield better results.