CS 280, Computer Vision (Prof. Jitendra Malik) April 7, 1999
Lecture #20 (Texture Discrimination and Edge Detection) **DRAFT** Notes by Shawn Hsu

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- Texture Discrimination
- Edge Detection

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1 Texture Discrimination

1.1 Textons

Textons are used to differentiate regions with different textures or patterns. Three characteristics of textons are used:

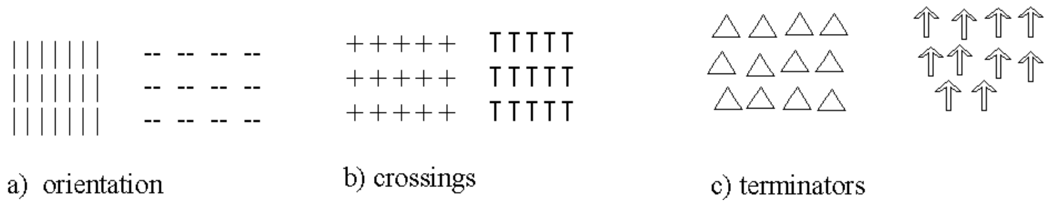

Figure 1: Textons

1.2 Pre-attentive texture discrimination

(10ms - 30ms)

- Not much reasoning is possible
- Most of the image processing is done by V1

V1 cells respond to:

- **Oriented Edges** ($Rot_\theta \quad G_{\sigma_1}(x)G'_{\sigma_2}(y)$)
- **Oriented Bars** ($Rot_\theta \quad G_{\sigma_1}(x)G''_{\sigma_2}(y)$)
- **Dots** ($Rot_\theta \quad G'_{\sigma_1}(x)G''_{\sigma_2}(y)$)

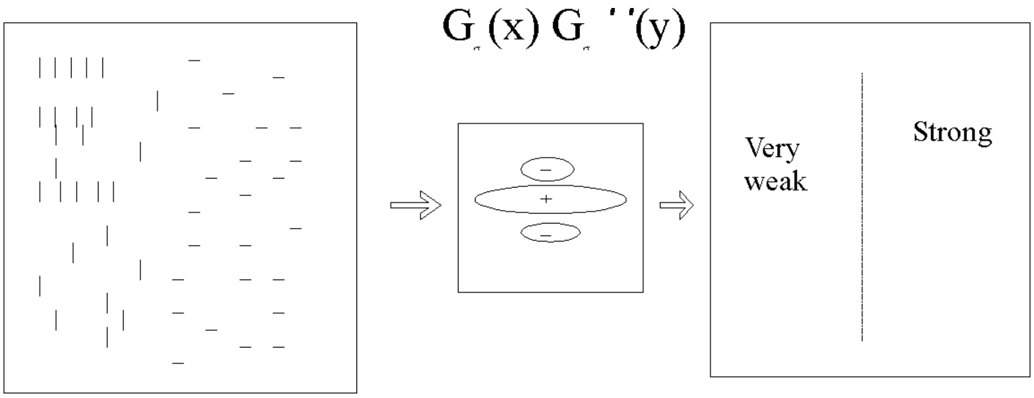

Figure 2: Texture Discrimination Example

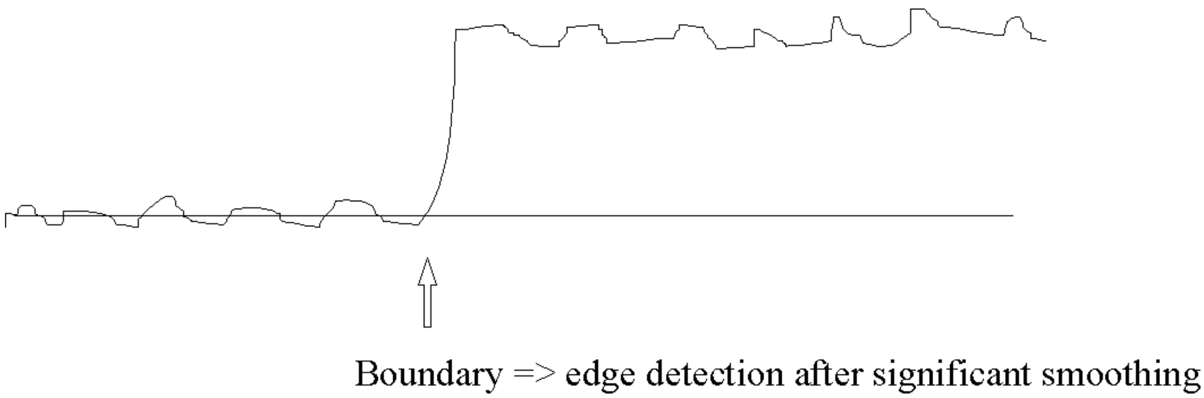

Figure 3: Cross Section

2 Edge Detection

2.1 Edge Detection in Different Orientations

If there is an edge in any of the channels in Figure 4, then you declare an edge in the image. The edge detectors are arrayed in different orientations. This is done to detect edges in the different orientations.

2.2 Using histograms to detect edges

Since we smooth the images, images that have the same mean would end up looking the same, even though they can have different edges (See Figure 5).

Therefore, instead of looking at the mean, we look at the distribution of intensity values. We use histograms to determine the intensity values which occur the most frequent in the image. As shown in Figure 6, the two images have the same mean (0.8), but it's obvious that the two images are not the same. If we just use regular smoothing, then we would not be able to detect any difference between the first image and the second image. However, we can use histograms to see a difference between these images. The histograms show that the first image contains many pixels with intensity values around 0.5 and 1, while the second

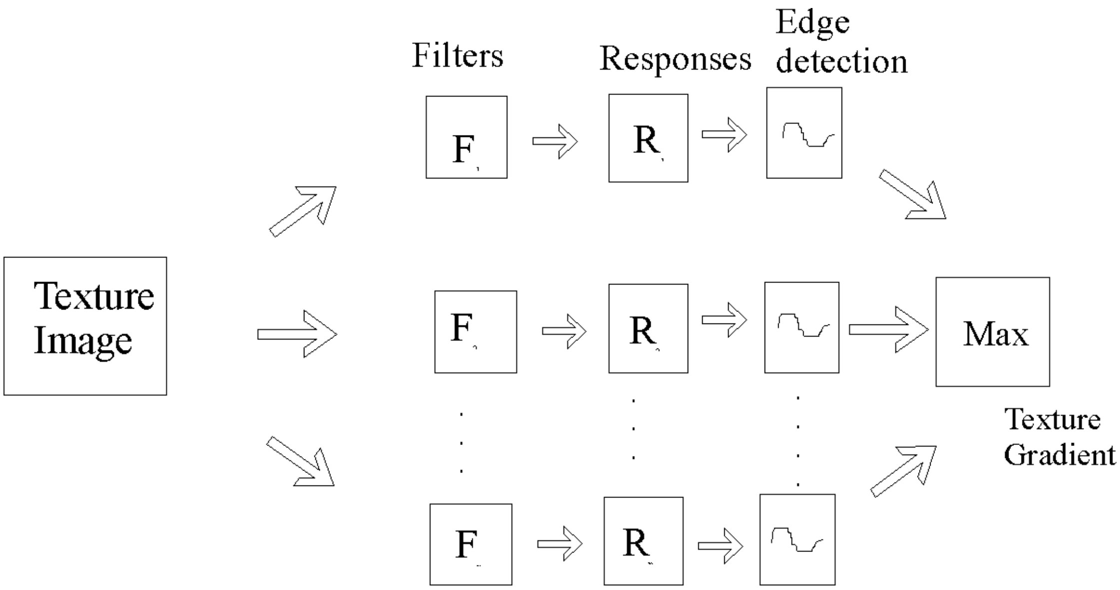

Figure 4: Edge Detection in Different Orientations

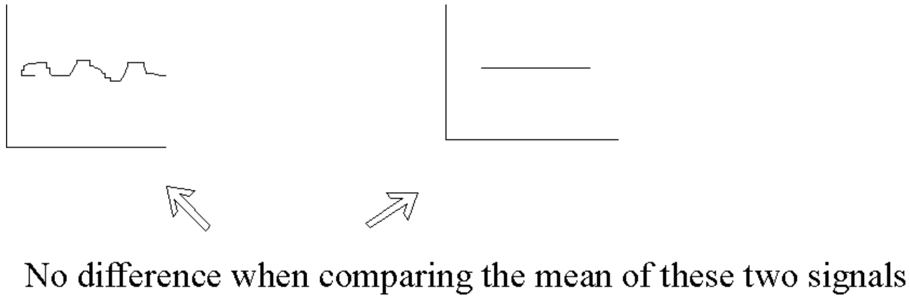

Figure 5: Problem with Differentiating Images with the Same Mean

image has pixels with intensity values around 0.8.

We can use Chi-Square (X^2) for comparing histograms:

$$d(h_1, h_2) = \sum_{n=1}^{N} \frac{[h_1(n) - h_2(n)]^2}{[h_1(n) + h_2(n)]} \tag{1}$$

h_1 : first image
h_2 : second image
N : number of bins

We plot a histogram for each section of the image, by sampling the image using different windows. The edges occur where the histogram changes between two successive windows.

2.3 Elongated Filters

Rule of Thumb: for $G_{\sigma_1}(x)$ *and* $G'_{\sigma_2}(y)$, the ratio of $\sigma_1 : \sigma_2$ is 3:1

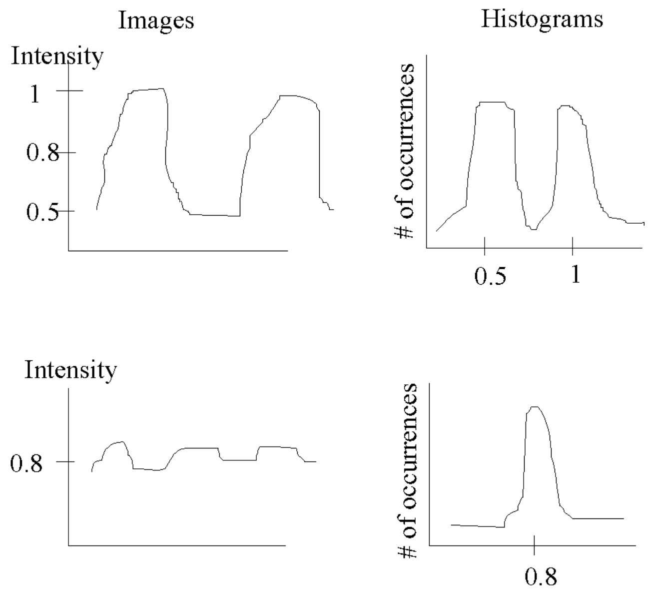

Figure 6: Two Images with the Same Mean

Suppose we have:

- Edges with contrast [0...5]. Contrast is the difference between pixel intensity.
- Noise with mean of 0 and $\sigma = \frac{1}{2\sqrt{2}}$

  $\sum_{i=1}^{N} r_i = N(0, \sqrt{N}\sigma)$

  if r_i = N(0,σ)

If we use the filter shown in part (A) of Figure 9 we get the equation $x_2 - x_1 = N(0, \frac{1}{2})$ just from the noise. If we set threshold to 1, then we would miss 20% of the edges, and get about 5% false positives (2 standard deviations from the mean). If we set threshold to 1.5, then the miss rate becomes 30%, and false positives 1% (about 3 std away from mean). We want to push the curve down, to the ideal spot where there would be no misses and no false positives (shown in Figure 7).

Now let's look at an elongated filter like the one in part (B) of Figure 9. What kind of result will we get if we use this filter on an image like the one in Figure 8? Filter (b) has a reponse to edge of $4 * (stepsize)$. Since the step size is equal to 5, the response to edge is from 0 to 20. If we use threshold = 2, the percentage of misses is 10%, and false positives 5%. If we raise the threshold to 3, the miss rate becomes 15% and false positives 1%. This pushes the curve down.

SNR (Signal to Noise Ratio) gets better as false positives and misses decrease. However, if the length of the filter is too long, then there would be problems at edges and curved boundaries. Therefore, the rule of thumb is 3:1 for $\sigma_1 : \sigma_2$.

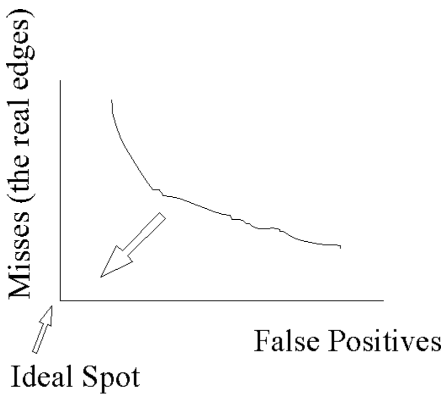

Figure 7: Misses to False Positives Plot

Figure 8: Sample Image

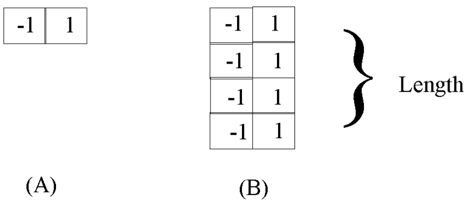

Figure 9: Comparison of Two Filters