Chapter 10
Image Segmentation

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- **The whole is equal to the sum of its parts.**

  -**Euclid**

- **The whole is greater than the sum of its parts.**

  -**Max Wertheimer**

- **The Whole is Not Equal to the Sum of Its Parts: An Approach to Teaching the Research Paper.**

  -by Mangum, Bryant

- **Detection of Discontinuities**
- **Edge Linking and Boundary Detection**
- **Thresholding**
- **Region-Based Segmentation**
- **Segmentation by Morphological Watersheds**
- **The Use of Motion in Segmentation**

- Spatial Techniques
- Frequency Domain Techniques

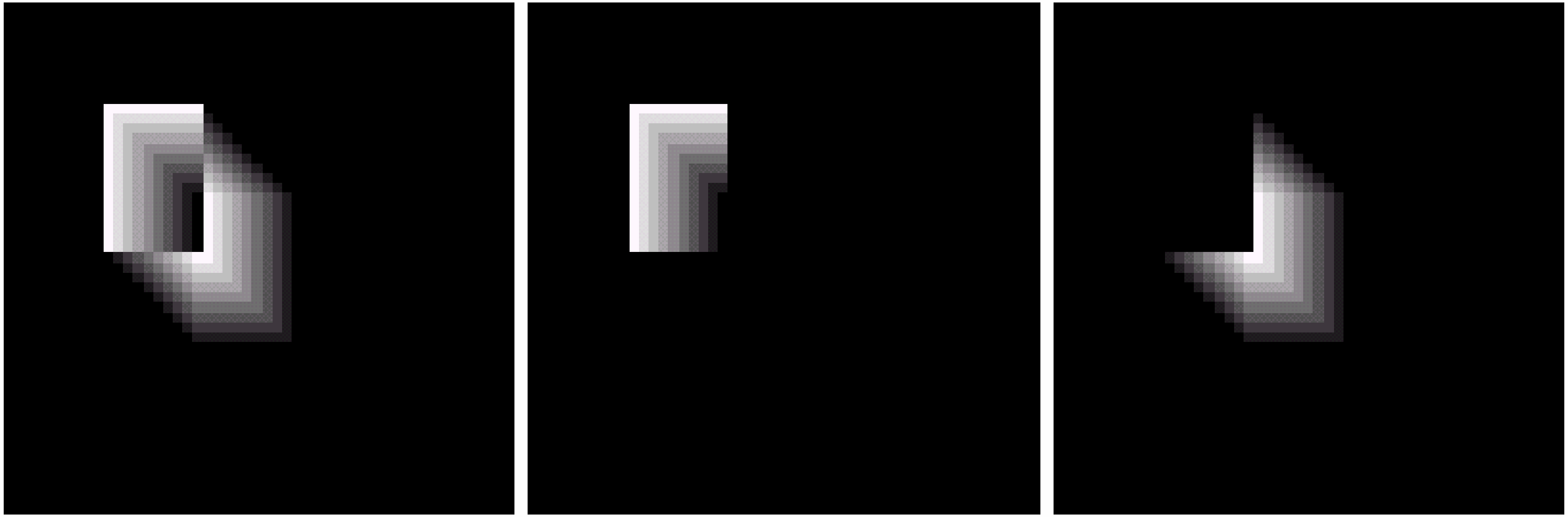
$$d_{ij}(x,y) = \begin{cases} 1 & \text{if} \quad \left| f(x,y,t_i) - f(x,y,t_j) \right| > T \\ 0 & \text{otherwise} \end{cases}$$

- $$A_k(x,y) = \begin{cases} A_{k-1}(x,y) + 1 & if \quad \left| R(x,y) - f(x,y,k) \right| > T \\ A_{k-1}(x,y) & otherwise \end{cases}$$

$$P_k(x,y) = \begin{cases} P_{k-1}(x,y) + 1 & if \quad \left| R(x,y) - f(x,y,k) \right| > T \\ P_{k-1}(x,y) & otherwise \end{cases}$$

- and

$$N_k(x,y) = \begin{cases} N_{k-1}(x,y) + 1 & if \quad \left| R(x,y) - f(x,y,k) \right| < -T \\ N_{k-1}(x,y) & otherwise \end{cases}$$



a b c

FIGURE 10.49 ADIs of a rectangular object moving in a southeasterly direction. (a) Absolute ADI. (b) Positive ADI. (c) Negative ADI.

a b c

FIGURE 10.50 Building a static reference image. (a) and (b) Two frames in a sequence. (c) Eastbound automobile subtracted from (a) and the background restored from the corresponding area in (b). (Jain and Jain.)

- Spatial Techniques
- Frequency Domain Techniques

$$e^{j2\pi a_1 (x'+t)\Delta t} = \cos[2\pi a_1 (x'+t)\Delta t] + j\sin[2\pi a_1 (x'+t)\Delta t]$$

$$g_x(t, a_1) = \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} f(x, y, t) e^{j2\pi a_1 x \Delta t} \qquad t = 0, 1, \ldots, K-1. \qquad (10.6\text{-}6)$$

Similarly, the sum of the projections onto the y-axis is

$$g_y(t, a_2) = \sum_{y=0}^{N-1} \sum_{x=0}^{M-1} f(x, y, t) e^{j2\pi a_2 y \Delta t} \qquad t = 0, 1, \ldots, K-1 \qquad (10.6\text{-}7)$$

The 1-D Fourier transforms of Eqs. (10.6-6) and (10.6-7), respectively, are

$$G_x(u_1, a_1) = \frac{1}{K} \sum_{t=0}^{K-1} g_x(t, a_1) e^{-j2\pi u_1 t/K} \qquad u_1 = 0, 1, \ldots, K-1 \qquad (10.6\text{-}8)$$

and

$$G_y(u_2, a_2) = \frac{1}{K} \sum_{t=0}^{K-1} g_y(t, a_2) e^{-j2\pi u_2 t/K} \qquad u_2 = 0, 1, \ldots, K-1. \qquad (10.6\text{-}9)$$

- The frequency-velocity relationship is

$$u_1 = a_1 v_1$$

and

$$u_2 = a_2 v_2.$$

- The actural physical speed in the x-dirextion is

$$\begin{aligned} v_1 &= (10 \text{ pixels})(0.5 \text{ m/pixel})(2 \text{ frames/s})/(30 \text{ frames}) \\ &= 1/3 \text{ m/s}. \end{aligned}$$

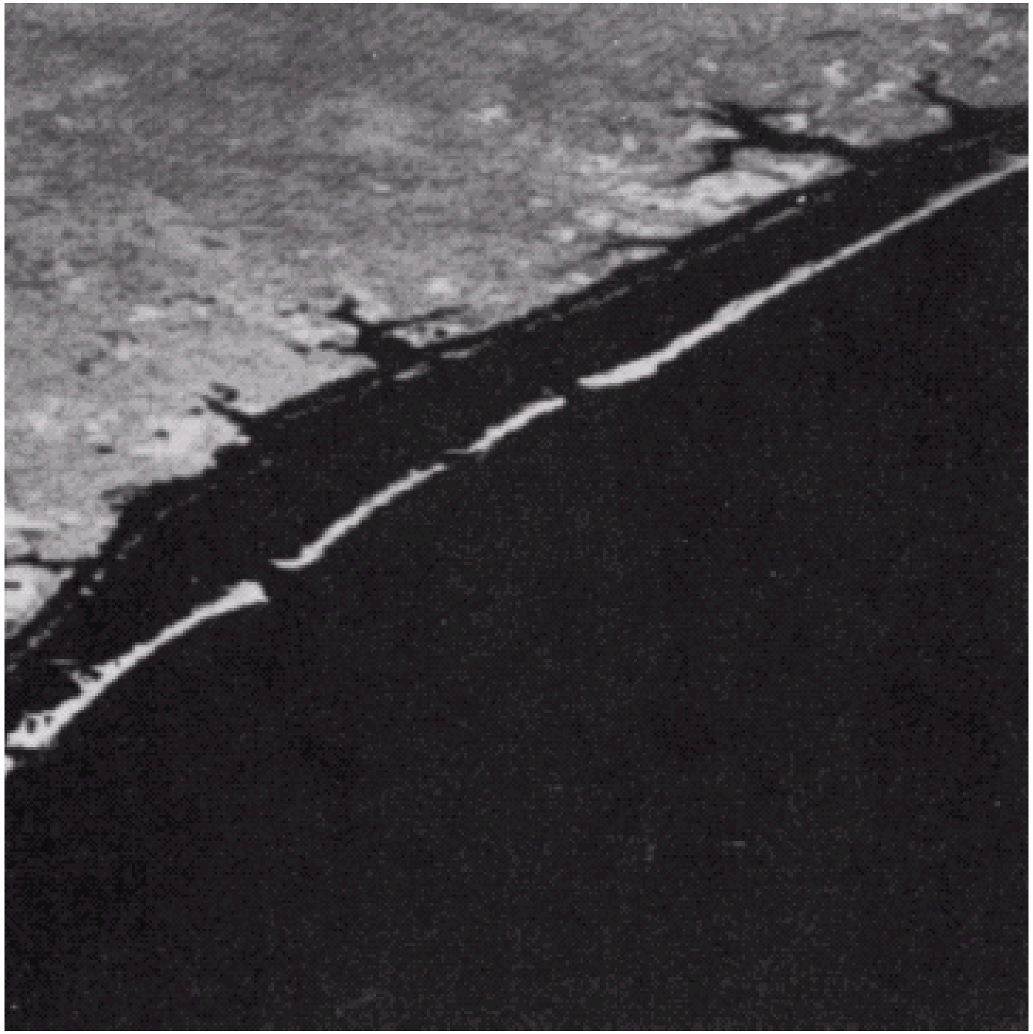
The sign of the x-component of the velocity is obtained by computing

$$S_{1x} = \left. \frac{d^2 \mathrm{Re}\left[g_x(t, a_1)\right]}{dt^2} \right|_{t=n} \qquad (10.6\text{-}12)$$

and

$$S_{2x} = \left. \frac{d^2 \mathrm{Im}\left[g_x(t, a_1)\right]}{dt^2} \right|_{t=n} \qquad (10.6\text{-}13)$$

FIGURE 10.51 LANDSAT frame. (Cowart, Snyder, and Ruedger.)



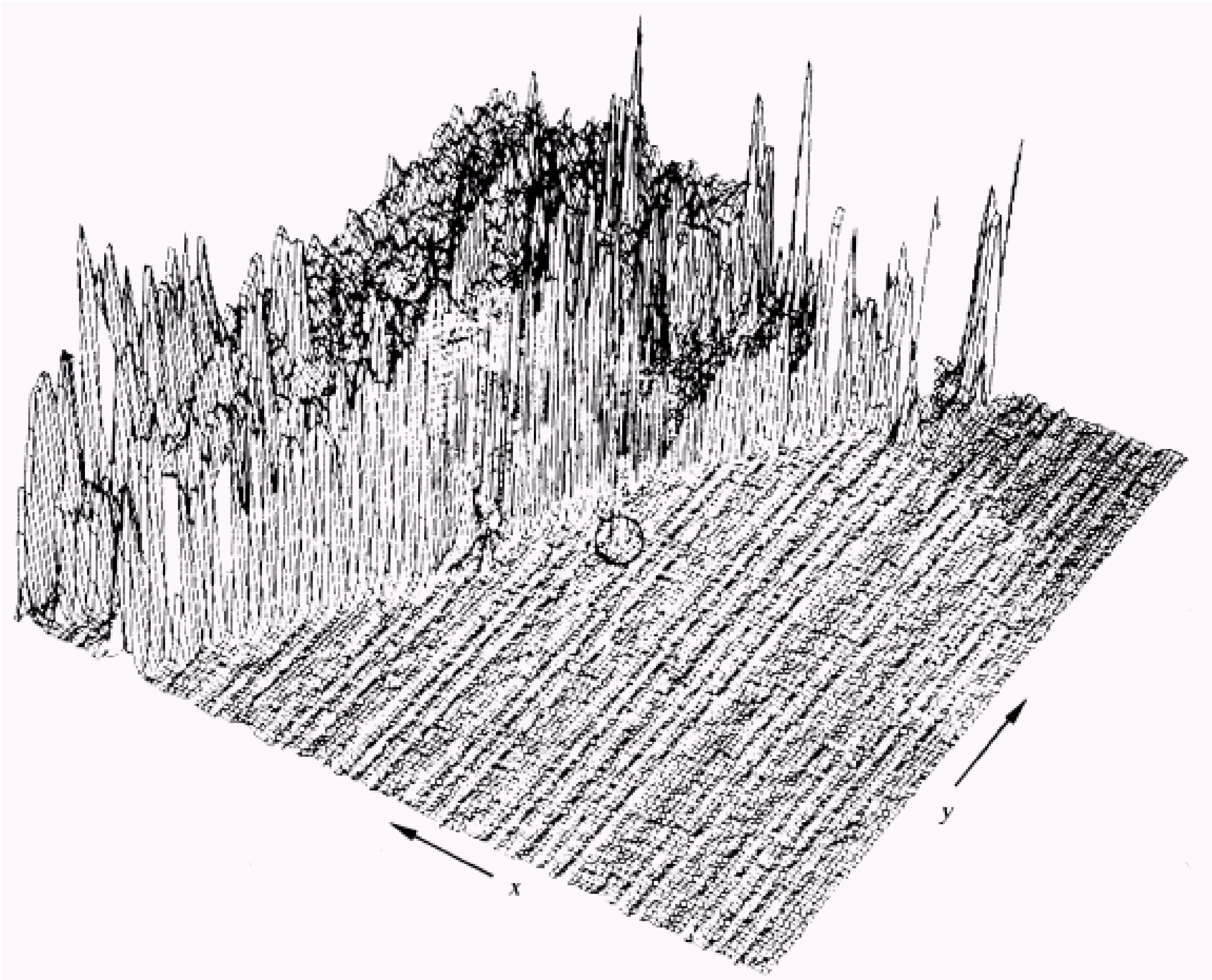


FIGURE 10.52 Intensity plot of the image in Fig. 10.51, with the target circled. (Rajala, Riddle, and Snyder.)

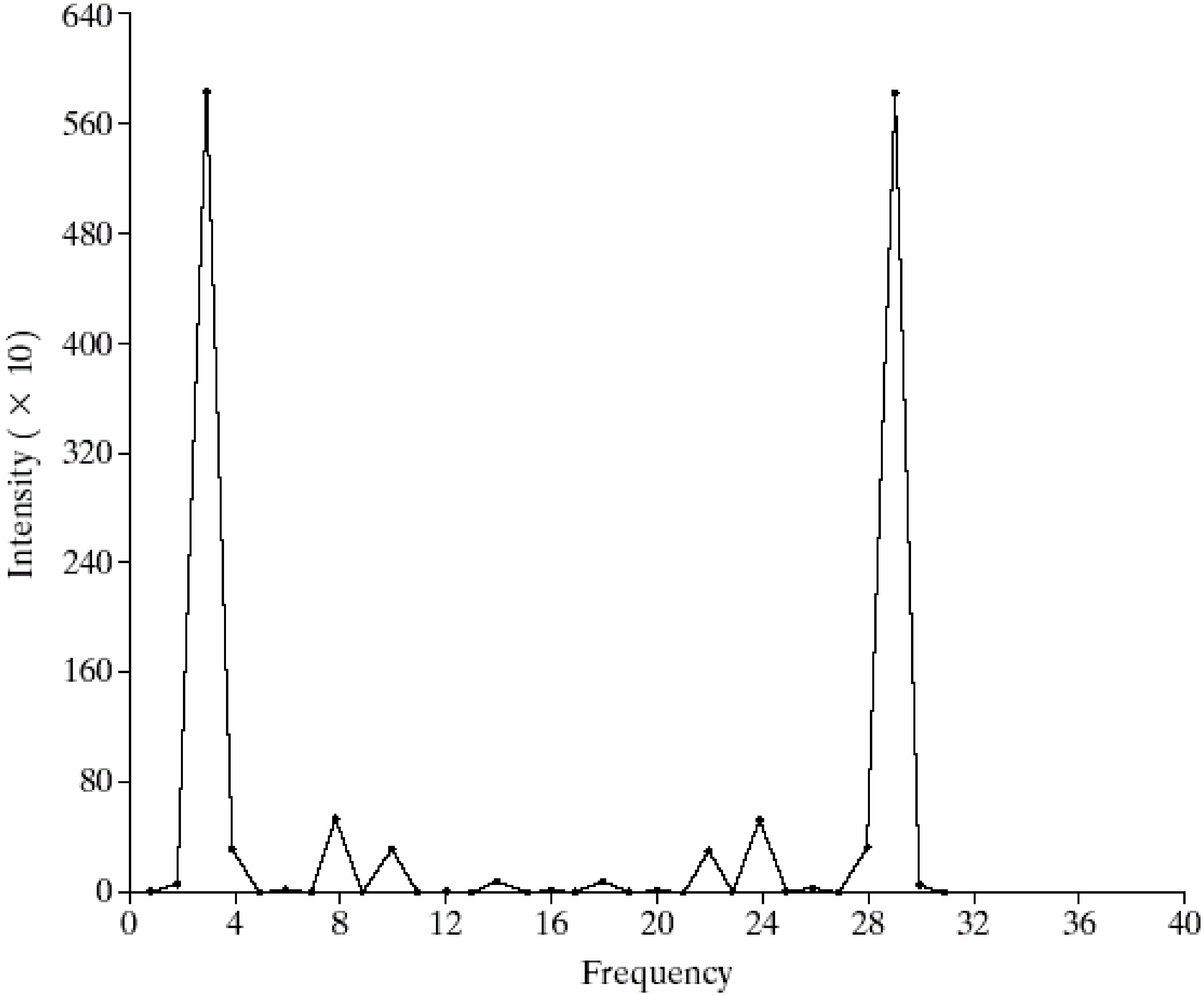


FIGURE 10.53 Spectrum of Eq. (10.6-8) showing a peak at $u_1 = 3$. (Rajala, Riddle, and Snyder.)

FIGURE 10.54 Spectrum of Eq. (10.6-9) showing a peak at $u_2 = 4$. (Rajala, Riddle, and Snyder.)