EEE-6512: Image Processing and Computer Vision

September 4, 2018
Lecture #3: Digital Image Fundamentals Pt. 2
Damon L. Woodard, Ph.D.
Dept. of Electrical and Computer Engineering
dwoodard@ece.ufl.edu

Outline

- **Section 2.4:** Image Sampling and Quantization
- **Section 2.5:** Some Basic Relationships Between Pixels

Image Sampling and Quantization

- **Interpolation** is the process of using known data to estimate the values at unknown locations.
- Typically used for image shrinking and zooming, geometric transformations, and image inpainting (error concealment).
- **Nearest-neighbor** interpolation assigns to each location the intensity of its nearest neighbor in the original image.
- **Bilinear interpolation** uses the intensities of four nearest neighbors to estimate the intensity at a new location.
- **Bicubic interpolation** uses the intensities of sixteen nearest neighbors to estimate the intensity at a new location.

Image Sampling and Quantization

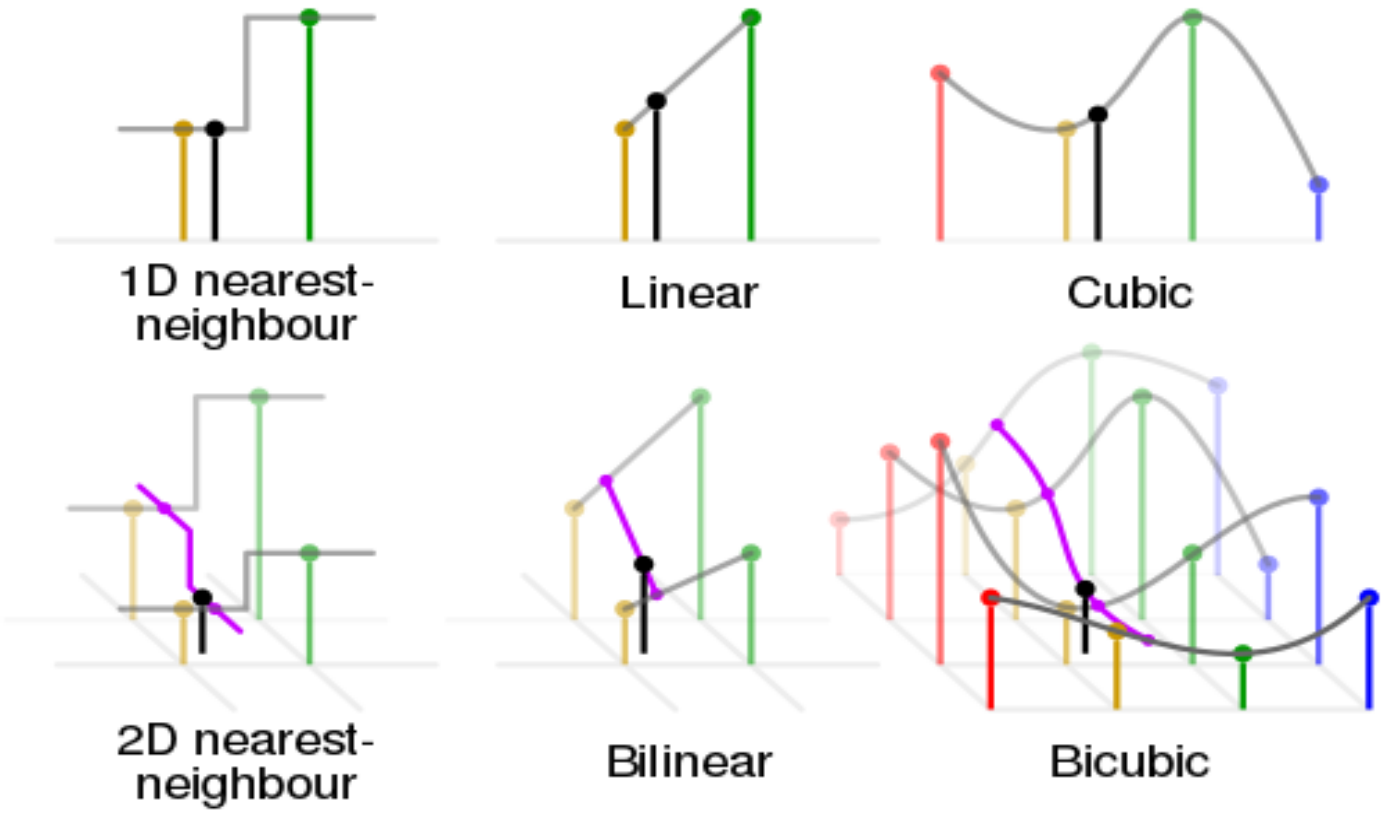


Image Sampling and Quantization

a b c

FIGURE 2.27 (a) Image reduced to 72 dpi and zoomed back to its original 930 dpi using nearest neighbor interpolation. This figure is the same as Fig. 2.23(d). (b) Image reduced to 72 dpi and zoomed using bilinear interpolation. (c) Same as (b) but using bicubic interpolation.

Image Sampling and Quantization

- **Nearest Neighbor Interpolation**
  - **Advantage**
    - Simple to compute
    - Sample value does not change
  - **Disadvantage**

    Tends to increase noise and produce jagged boundaries

Bilinear Interpolation

- **Advantages**
  - Image looks smoother than nearest neighbor interpolation
  - More accurate than nearest neighbor interpolation
- **Disadvantage**
  - Alters original data and reduces contrast and high frequency components of image
  - Computationally more expensive than nearest neighbor interpolation

Image Sampling and Quantization

Bicubic Interpolation

- **Advantages**
  - Image looks smoother than bilinear interpolation
  - More accurate than nearest neighbor and bilinear interpolation
- **Disadvantages**
  - Alters original data and reduces contrast and high frequency components of image
  - Computationally more expensive and slower than previous methods

Some Basic Relationships Between Pixels

Some Basic Relationships Between Pixels

- A pixel ***p*** at coordinates *(x,y)* has two horizontal and two vertical neighbors with coordinates:
  - *(x+1,y), (x-1,y), (x,y+1), (x,y-1)*
- These are the four-neighbors of ***p***, and denoted as $N_4(\boldsymbol{p})$.

- The four diagonal neighbors of ***p*** have the coordinates:
  - *(x+1,y+1), (x+1,y-1), (x-1, y+1), (x-1,y-1)*
- These are denoted as $N_D(\boldsymbol{p})$

- $N_4(\boldsymbol{p}) + N_D(\boldsymbol{p}) = N_8(\boldsymbol{p})$

Some Basic Relationships Between Pixels

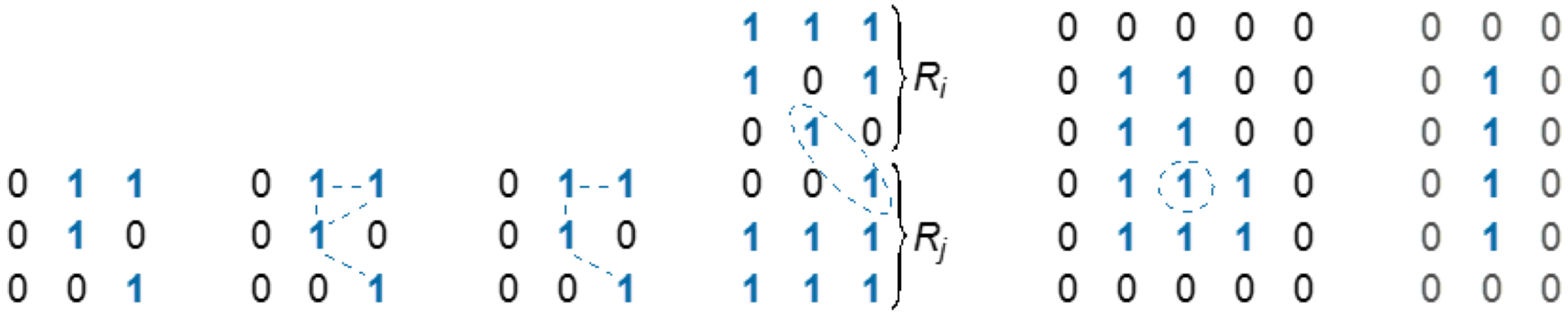
- Let *V* be the set of intensity values used to define adjacency. We consider three types of adjacency:

- **4-adjacency** Two pixels ***p*** and ***q*** with values from V are 4-adjacent if ***q*** is in the set $N_4(\boldsymbol{p})$.

- **8-adjacency** Two pixels ***p*** and ***q*** with values from V are 8-adjacent if ***q*** is in the set $N_8(\boldsymbol{p})$.

- **m-adjacency** Two pixels ***p*** and ***q*** with values from V are m-adjacent if
- (a) **q** is in $N_4(\boldsymbol{p})$ or
- (b) **q** is in $N_D(\boldsymbol{p})$ and the set $N_4(\boldsymbol{p}) \cap N_4(\boldsymbol{q})$ has no pixels whose value is from V.

Some Basic Relationships Between Pixels



a b c d e f

FIGURE 2.28 (a) An arrangement of pixels. (b) Pixels that are 8-adjacent (adjacency is shown by dashed lines). (c) *m*-adjacency. (d) Two regions (of 1's) that are 8-adjacent. (e) The circled point is on the boundary of the 1-valued pixels only if 8-adjacency between the region and background is used. (f) The inner boundary of the 1-valued region does not form a closed path, but its outer boundary does.

Some Basic Relationships Between Pixels

A digital path (or curve) from pixel ***p*** with coordinates (x_0,y_0) to pixel ***q*** with coordinates (x_n,y_n) is a sequence of distinct pixels with coordinates:

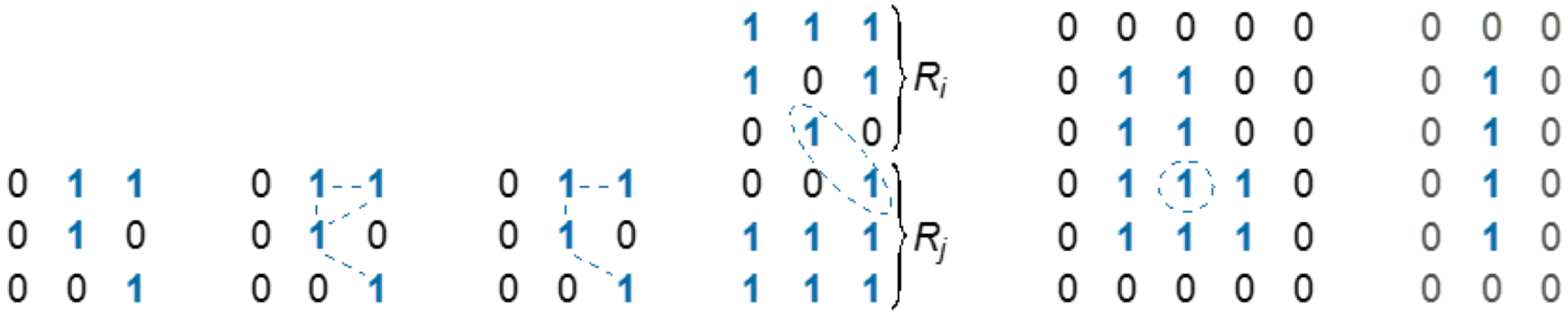
$$(x_0,y_0),\ (x_1,y_1),\ \ldots.,\ (x_n,y_n)$$

where points (x_i,y_i) and (x_{i-1},y_{i-1}) are adjacent for $1 \leq i \leq n$.

If $(x_0,y_0) = (x_n,y_n)$ then the path is closed.

Let *S* represents a subset of pixels in an image. Two pixels ***p*** and ***q*** are said to be connected in *S* if there exists a path between them existing entirely of pixels in *S*.

Some Basic Relationships Between Pixels



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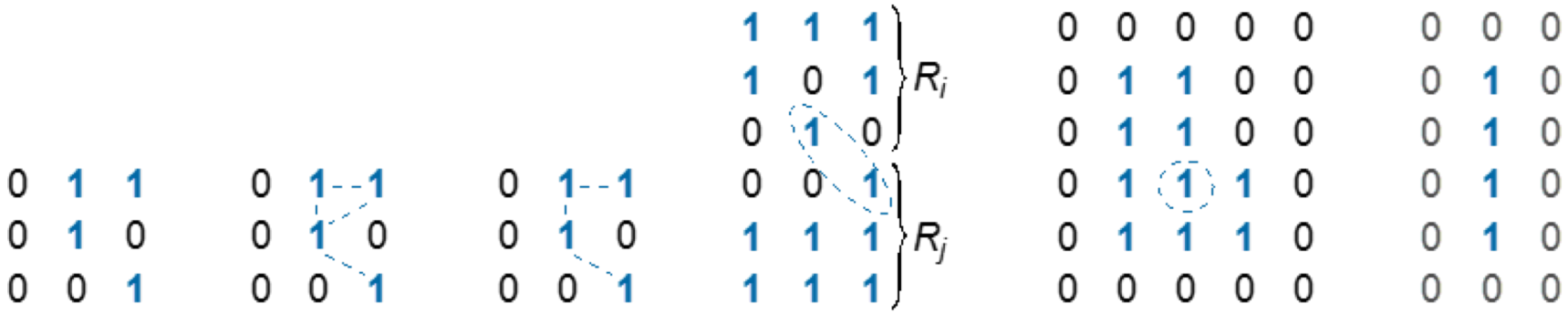
Some Basic Relationships Between Pixels

- Let R represent a subset of pixels in the image. We call R a region of the image if R is a connected set.
- Two regions R_i *and* R_j are said to be adjacent if their union forms a connected set.
- Regions that are not adjacent are said to be disjoint.
- We consider 4-adjacency and 8-adjaceny when referring to regions.

Some Basic Relationships Between Pixels



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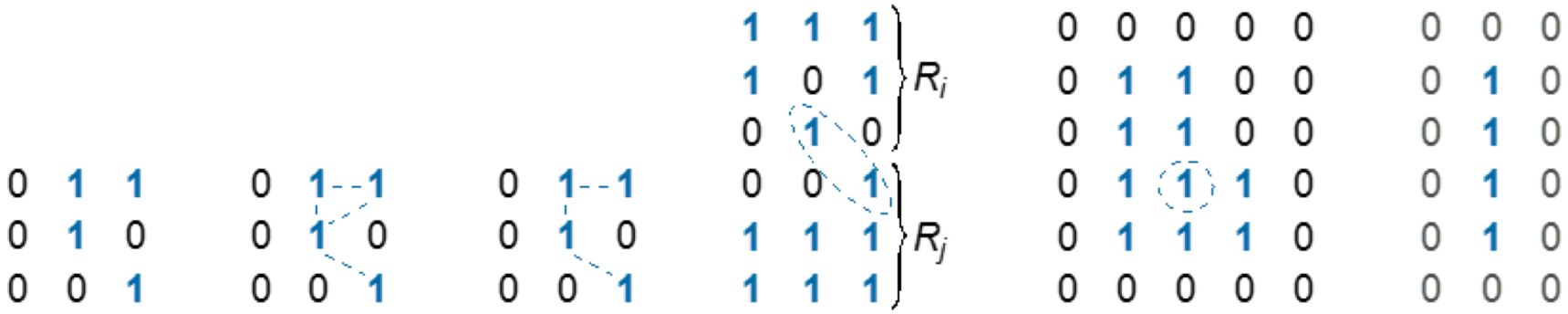
Some Basic Relationships Between Pixels

- The boundary (also called the border or contour) of a region *R* is the set of pixels in *R* that are adjacent to the complement of *R*.
- Another way to state this is that the border of a region is the set of pixels in the region that have at least one background neighbor.
- Must define the connectively used for determining adjacency.
- This definition of the boundary is sometime referred to as the **inner border**.
- The **outer border** is the corresponding border in the background.

Some Basic Relationships Between Pixels



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Next Time: Chapter 3: Spatial Filtering

Questions?