**University of Utah, CS/BIOEN 6640 Image Processing**

**Fall 2012, Prof. Guido Gerig**

**Quizz 1: 9/19/2012**

**Student Name:** ________________________________

---

## 1.1 Representing Digital Images:

Which of the following applies?

| | Amplitude intensity values | Spatial coordinates |
|---|---|---|
| Sampling | ☐ | ☒ |
| Quantization | ☒ | ☐ |

---

## 1.2 Number of gray levels:

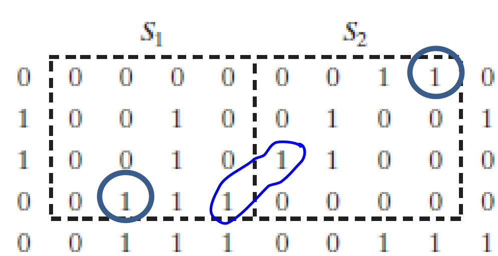
An 8bit image of 512x512 pixels has how many discrete intensity levels?: 256.

---

## 2. Basic Relationships between Pixels:

Recall the notation from the book: “Let V be the set of intensity values used to define adjacency: In a binary image, V={1} if we are referring to adjacency of pixels with value 1. In a gray-scale image, V typically contains more elements” and is given as V={k,l}.

### 2.1 Adjacency I




Consider the two image subsets, *S*1 and *S*2, shown in the following figure. For V={1}, determine whether these two subsets are

(a) ☐ 4-adjacent, $d_4$

(b) ☒ 8-adjacent, $d_8$

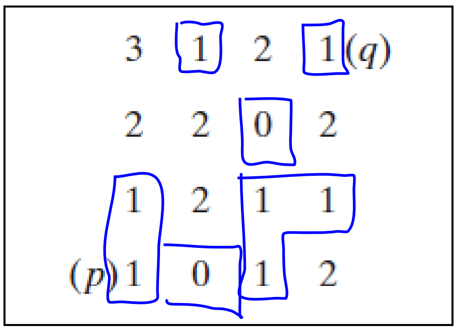
c) What is the minimum path length between the circled locations in the metric of result (a) or (b) 6 .and in the Euclidan metric: .

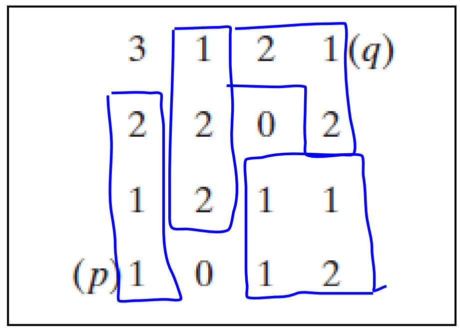
## 2.2 Adjacency II

Consider the image segment shown.

**(a)** Let V={0, 1} and compute the lengths of the shortest 4- and 8-path between p and q. Draw your solution on copied versions of the template image. If a particular path does not exist say so.

**(b)** Repeat for V={1, 2}.




**V={0, 1}**: Length 4path: \ Length 8path: 4 **V={1, 2}:** Length 4path: 6 Length 8path: 4

## 3.1 Histogram Processing:

Suppose that a digital image is subjected to histogram equalization. You have the idea to do a second pass of histogram equalization on the result of the first pass: What would you expect your result to be?

- ☒ A second pass of histogram equalization will produce exactly the same result as the first pass.
- ☐ A second pass would further improve the result.

### 3.2 Histogram and probability density function (pdf):

The integral or sum, respectively, of the histogram or pdf sum up to:

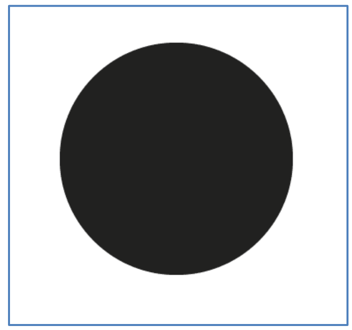
| | #pixels in image | 1.0 |
|---|---|---|
| Histogram | ☒ | ☐ |
| pdf | ☐ | ☒ |

### 4.1 Image Filtering

The image gradient and its magnitude are given as follows:

$$\nabla \mathbf{f} = \begin{bmatrix} G_x \\ G_y \end{bmatrix} = \begin{bmatrix} \frac{\partial f}{\partial x} \\ \frac{\partial f}{\partial y} \end{bmatrix}$$

$$|\nabla f| = \text{mag}(\nabla \mathbf{f}) = [G_x^2 + G_y^2]^{1/2} = \left[ \left( \frac{\partial f}{\partial x} \right)^2 + \left( \frac{\partial f}{\partial y} \right)^2 \right]^{1/2}$$



Given is an image object shaped like a disk. Would you walk around the disk's boundary from top all around, what do you expect to see w.r.t. the partial derivatives and the gradient magnitude?

**Partial derivatives:**

- ☐ df/dx and df/dy stays the same at locations around the disk boundary
- ☒ df/dx and df/dy vary at different locations around the disk boundary

**Gradient magnitude:**

- ☐ varies at locations around the disk boundary
- ☒ stays the same at locations around the disk boundary

### 4.2 Image Filtering

Let us apply linear filters with equal weights to reduce noise in an image g(x,y) which is characterized by g(x,y) = f(x,y) + η(x,y), where the noise η(x,y) is uncorrelated, has zero mean and variance $\sigma^2_{\eta(x,y)}$.

Let us apply 3x3 and 5x5 filters with equal weights. What can you say about the variance and standard deviation of noise in the filtered images?

- 3x3 box filter: change of variance $1/9$, change of standard deviation $\sqrt{\frac{1}{9}}$. $= \frac{1}{3}$
- 5x5 box filter: change of variance $1/25$, change of standard deviation $\frac{1}{\sqrt{25}}$. $= \frac{1}{5}$