Assignments/Announcements

• Lab #1 due BY HARDCOPY IN CLASS on Mon. Sept. 25.

• HW #2 due by hardcopy in class on Wed. Sept. 27.
Computer Vision Talk

- Talk: Fun Research in Computer Vision and Robotics
- Speaker: Prof. Takeo Kanade,
  Robotics Institute, Carnegie Mellon University
- When: 10:15-11:30am, Tuesday, Sept. 26.
- Where: COB 120
- More info on Prof. Kanade:
EECS Seminar

• Talk: Urban Impervious Surface Extraction Using High-Resolution Remote Sensing Images
• Speaker: Dr. Zhenfeng Shao
  State Key Laboratory of Information Engineering in Surveying, Mapping and Remote Sensing, Wuhan University, China
• When: noon~1pm, Friday, Sept. 22.
• Where: COB1 (CLSSRM) 263
• More info: http://eecs.ucmerced.edu/seminars
Questions?
Today

• Chap. 2: Digital Image Fundamentals (continued)
Chap 2: Some basic relationships between pixels

• Neighbors of a pixel
  – $N_4(p) = 4$-neighbors of $p$
  – $N_8(p) = 8$-neighbors of $p$

• Used in defining sets of pixels
  – Adjacency, connectivity, regions, boundaries
Chap 2: Some basic relationships between pixels

- **Adjacency**
  - Two pixels $p$ and $q$ are **4-adjacent** if $q \in N_4(p)$ and their values satisfy a given constraint.
  - Two pixels $p$ and $q$ are **8-adjacent** if $q \in N_8(p)$ and their values satisfy a given constraint.
  - Two pixels are **m-adjacent** if their values satisfy a given constraint and
    1. $q \in N_4(p)$, or
    2. $q \in N_8(p)$ and the set $N_4(p) \cap N_4(q)$ has no pixels that satisfy the constraint.
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• A **path** from pixel p at (x,y) to pixel q at (s,t) is a sequence of distinct pixels with coordinates

  \[(x_0, y_0), (x_1, y_1), \ldots, (x_n, y_n)\]

  where

  1. \((x_0, y_0) = (x, y)\)
  2. \((x_n, y_n) = (s, t)\) and
  3. pixels \((x_n, y_n)\) and \((x_{n-1}, y_{n-1})\) are adjacent for \(1 \leq i \leq n\)

• \(n\) is the **length** of the path

• If \((x_0, y_0) = (x_n, y_n)\) then the path is a **closed** path

• Can define 4-, 8-, or m-paths
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- Paths

```
0 1 1
0 1 0
0 0 1
```

```
0 1--1
0 1 0
0 0 1
```

```
0 1--1
0 1 0
0 0 1
```
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• **Connectedness**

• Let $S$ be a set of pixels in an image
  – $p$ and $q$ are **connected** in $S$ if $\exists$ a path between them consisting entirely of pixels in $S$
  – For any pixel $p \in S$, the set of pixels that are connected to it in $S$ is called a **connected component** of $S$
  – If $S$ has only one connected component then $S$ is called a **connected set**

• $S$ is typically the entire image
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• **Regions**

• R is a region in an image if R is a connected set

• Two regions, $R_i$ and $R_j$ are adjacent if their union forms a connected set

• Regions that are not adjacent are disjoint

• Region adjacency is defined with respect to either 4-adjacency or 8-adjacency
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• Regions

```
1 1 1
1 0 1
0 1 0
0 0 1
1 1 1
1 1 1
```

$R_i$

$R_j$
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- Region boundaries
- The **boundary** of a region $R$ is the set of points (in $R$) which are adjacent to points in the complement of $R$
- A boundary is defined in terms of 4- or 8-adjacency
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• Boundaries

```
0 0 0 0 0
0 1 1 0 0
0 1 1 0 0
0 1 1 0 0
0 1 1 0 0
```

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• **Distance measures** are used to calculate the spatial distance between pixel locations
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• Typically, distance measures are constrained to be metrics

• For pixels $p$, $q$, and $z$, with coordinates $(x,y)$, $(s,t)$, $(v,w)$, $D$ is a metric distance if
  1. $D(p,q) \geq 0$ (non-negativity)
  2. $D(p,q) = 0$ iff $p = q$
  3. $D(p,q) = D(q,p)$ (symmetry)
  4. $D(p,z) \leq D(p,q) + D(q,z)$ (triangle inequality)

• Constraint 1 is implied by the other 3
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• Examples of distance measures

• **Euclidean distance:**

\[
D_e(p, q) = \left[ (x - s)^2 + (y - t)^2 \right]^{1/2}
\]

• Pixels having a Euclidean distance less than or equal to some value \( r \) from \((x, y)\) are the points contained in a disk of radius \( r \) centered at \((x, y)\)
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- Examples of distance measures
- The $D_4$ distance (also called the city-block or Manhattan distance) between $p$ and $q$ is defined as

\[ D_4(p, q) = |x - s| + |y - t| \]

- The pixels having a $D_4$ distance from $(x,y)$ less than or equal to some value $r$ form a diamond centered at $(x,y)$
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- Examples of distance measures
- The $D_8$ distance (called the chessboard distance) between $p$ and $q$ is defined as

$$D_8(p, q) = \max \left( |x - s|, |y - t| \right)$$

- The pixels with $D_8$ distance from $(x,y)$ less than or equal to some value $r$ form a square centered at $(x,y)$. 