Image Processing and Computer Vision 1

Introduction – Image Representation in Memory – week 1

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1 Exercises from the Book

1.1 Book by Gonzalez and Woods, 2.11

A common measure of transmission for digital data is the *baud rate*, defined as symbolds (bits in our case) per second. As a minimum, transmission is accomplished in packets consisting of a start bit, a byte (8 bits) of information, and a stop bit. Using these facts, answer the following:

(a) How many seconds would it take to transmit a sequence of 500 images of size 1024×1024 pixels with 256 intensity levels using a 3 M-baud (10^6 bits/sec) baud model? (This is a representative medium speed for a DSL (Digital Subscriber Line) residential line.)

(b) What would the time be using a 30 G-baud (10^9 bits/sec) modem? (This is a representative medium speed for a commercial line.)

(a) The total amount of data (including the start and stop bits) in an 8-bit, 1024×1024 *image is* $(1024)^2 \times (8+2)$ *bits. The total time required to transmit 500 such images over a 3 M-baud modem is:*

$$\textit{Trans time} = 500 \times (1024)^2 \times (10)/(3 \times 10^6) = 1748 \ s$$

(b) Similarly,

$$\textit{Trans time} = 500 \times (1024)^2 \times (10)/(30 \times 10^9) = 0.1748 \ s$$

1.2 Book by Gonzalez and Woods, 2.16

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

(b) 8-adjacent

(c) m-adjacent

	S_1				S_2				
0	0	0	0	0	0	0	1	1	0
1	0	0	1	0	0	1	0	0	1
1	0	0	1	0	1	1	0	0	0
0	0	1	1	1	0	0	0	0	0
0	0	1	1	1	0	0	1	1	1

Let p and q be as shown in Fig. P2.16. Then,

(a) *S_1 and S_2 are not 4-connected because q is not in the set $N_4(p)$.*

(b) *S_1 and S_2 are 8-connected because q is in the set $N_8(p)$.*

(c) *S_1 and S_2 are m-connected because (i) q is in $N_D(p)$ and (ii) the set $N_4(p) \cap N_4(q)$ is empty.*

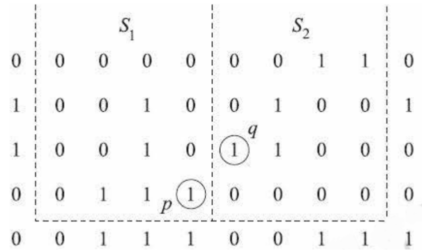

Figure P2.16

Note by the lecturer: Unfortunately, the autor of this exercise did not apply the stringent notation introduced in Chapter 2. Therefore, the task is not uniquely defined. However, the standard solution can be obtained when assuming the following modification of the problem statement: The subimages S_1 and S_2 contain the two connected components C_1 and C_2 who are composed of their pixels with values from the set $V = \{1\}$. These connected components C_1 and C_2 can be considered as Regions $R_1 = C_1$ and $R_2 = C2$. Two regions are adjacent if there is at least one pixel of R_1 that is adjacent to at least one pixel of R_2. Determine whether the two regions are 4-adjacent, 8-adjacent or m-adjacent.

1.3 Book by Gonzalez and Woods, 2.17

Develop an algorithm for converting a one-pixel thick 8-path to a 4-path.

The solution of this problem consists of defining all possible neighborhood shapes to go from a diagonal segment to a corresponding 4-connected segment, as Fig P2.17 illustrates. The algorithm then simply looks for the appropriate match every time a diagonal segment is encountered in the boundary.

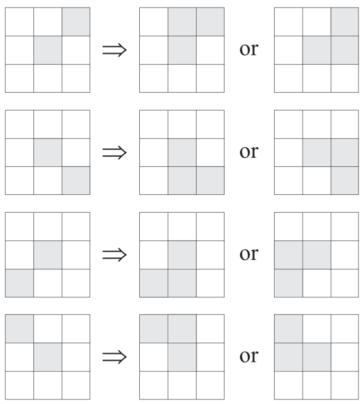

Figure P2.17

Note by the Lecturer: The result is not unique, i.e., multiple solutions are possible.

1.4 Book by Gonzalez and Woods, 2.20

Consider the image segment shown.

(a) Let $V = \{0, 1\}$ be the set of intensity values used to define adjacency. Compute the lengths of the shortest 4-, 8-, and m-path between p and q. If a particular path does not exist between these two points, explain why.

$$\begin{array}{ccccc} & 3 & 1 & 2 & 1 \quad (q) \\ & 2 & 2 & 0 & 2 \\ & 1 & 2 & 1 & 1 \\ (p) & 1 & 0 & 1 & 2 \end{array}$$

(a) When $V = \{0, 1\}$, a 4-path does not exist between p and q because it is impossible to get from p to q by traveling along points that are both 4-adjacent and also have values from V. Figure P2.20(a) shows this condition; it is not possible to get to q. The shortest 8-path is shown in Fig. P2.20(b); its length is 4. The length of the shortest m-path (shown dashed) is 5. Both of these shortest paths are unique in this case.

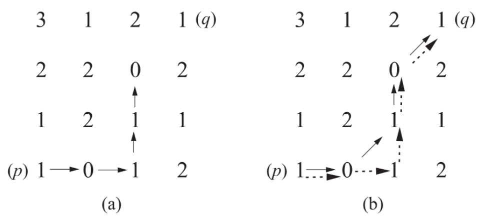

Figure P2.20

1.5 Book by Gonzalez and Woods, 2.21

Consider two points p and q

(a) State the condition(s) under which the D_4 distance between two points p and q is equal to the shortest 4-path between these points.

(b) Is this path unique?

(a) A shortest 4-path between a point p with coordinates (x, y) and a point q with coordinates (s, t) is shown in Fig. P2.21, where the assumption is that all points along the path are from V. The lengths of the segments of the path are $|x-s|$ and $|y-t|$, respectively. The total path length is $|x-s|+|y-t|$, which we recognize as the definition of the D_4 distance, as given in Eq. (2-20). (Recall that this distance is independent of any paths that may exist between the points.) The D_4 distance obviously is equal to the length of the shortest 4-path when the length of the path is $|x - s| + |y - t|$. This occurs whenever we can get from p to q by following a path whose elements (1) are from V, and (2) are arranged in such a way that we can traverse the path from p to q by making turns in at most two directions.

(b) The path may or may not be unique, depending on V and the values of the points along the way.

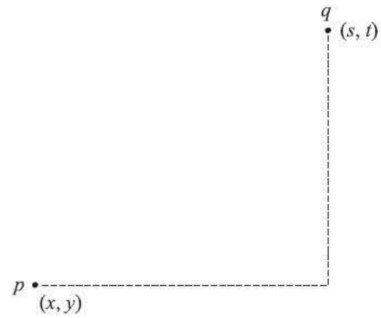

Figure P2.21